THE GLASS INDUSTRY

VOLUME 32, NUMBER 3, MARCH, 1951

GLASS SELECTION AND PRODUCTION TECHNIQUES FOR X-RAY AND OTHER TUBES

By M. J. ZUNICK, Engineer in Charge, and J. B. GOSLING, Glass Engineer

Tube Engineering Department, General Electric X-Ray Corporation, Milwaukee, Wisconsin

Abstract

The transition from soft lime glasses to the hard, borosilicate glasses to the specific glasses used in x-ray and valve tube manufacture is discussed. The parallel development of sealing metals for use with these glasses is also discussed.

The importance of certain electrical properties for specific tube applications and final processing to improve quality of hand blown bulbs are discussed. Some simple tests for physical properties are described in detail.

Glassworking equipment used in the x-ray industry is shown and various processes for working the heavy glass bulbs are described.

Historical

The x-ray tube, since its discovery by William Conrad Roentgen in 1896, has rapidly gone through a great many changes and the materials and techniques used in their production have had to keep pace with these changes.

Platinum was used for seals almost exclusively in x-ray tubes up to 1913 at the time William D. Coolidge discovered the hot-cathode type x-ray tube. Typical tubes of this period shown in Figs. 1a and 1b were made of various types of lime glass. The advent of the hot-cathode type x-ray tube brought about a number of problems. This new type of tube required high vacuum for proper operation and in time increased ratings added extreme stresses not only to the glass but also to the glass-to-metal seals. In the early models of the hot-cathode tube, Fig. 1c, the solid tungsten anode operated at a red heat so that bulbs of large diameter were necessary to prevent cave-in of the glass since the heat was dissipated nearly entirely by radiation through the center portion of the bulb. To improve cooling, anodes were redesigned wherein a tungsten target was embedded in a copper anode which extended through the tube to permit cooling by various types of radiators. Up to this time most tubes used only lead-in wires of platinum or "Dumet" (copper clad nickel-iron alloy) but some platinum sleeves were also used. Attempts were made to use copper sleeves of the Housekeeper type but, because of the heavy anodes required in x-ray tubes, they were not too successful mechanically.

A number of developments in the early nineteen thirties led to the production of early models of our modern x-ray tube. These developments included borosilicate (hard) glasses, general use of ferrous alloys for seals, particularly the development of the iron-nickel-cobalt alloy by Scott, commonly known as "Kovar" and "Fernico", and oil insulation. Tube designs were smaller for equivalent ratings since the tubes were cooled by the surrounding oil but the use of ever increasing voltages and current ratings actually resulted in the necessity for developing larger and larger tubes. Typical examples of tubes developed in the middle thirties are illustrated in Figs. 2a and 2b.

X-ray tubes are designed so that the electron beam generated at the cathode impinges on a relatively small area of the target (anode). Although x-rays are emitted in all directions, a small area of the glass bulb is designated as the window and is located to pass the portion of the beam selected for use. This window must have a minimum absorption for x-rays and in most cases a window with a uniform, minimum thickness is ground in the bulb. This precluded the use of lead glass for x-ray tubes and with only one exception lime glass was used in x-ray tubes until the hard glasses were introduced in the industry in the early thirties. The one exception was a small dental tube with a bulb made of lead glass. The window was made by bridging an open, pulled-out section at about the center of the bulb with a thin section of lime glass. Lead glass bulbs are desirable because they absorb a large amount of the stray radiation generated by the tube and reduce the amount of protection required for the tube casing.

By the beginning of World War II, hard glasses were used exclusively in the x-ray industry, types mainly used were 7050(705AJ), 7720(Nonex), 7740(Pyrex brand), and 3320(Uranium). Sealing metals that satisfied prac-

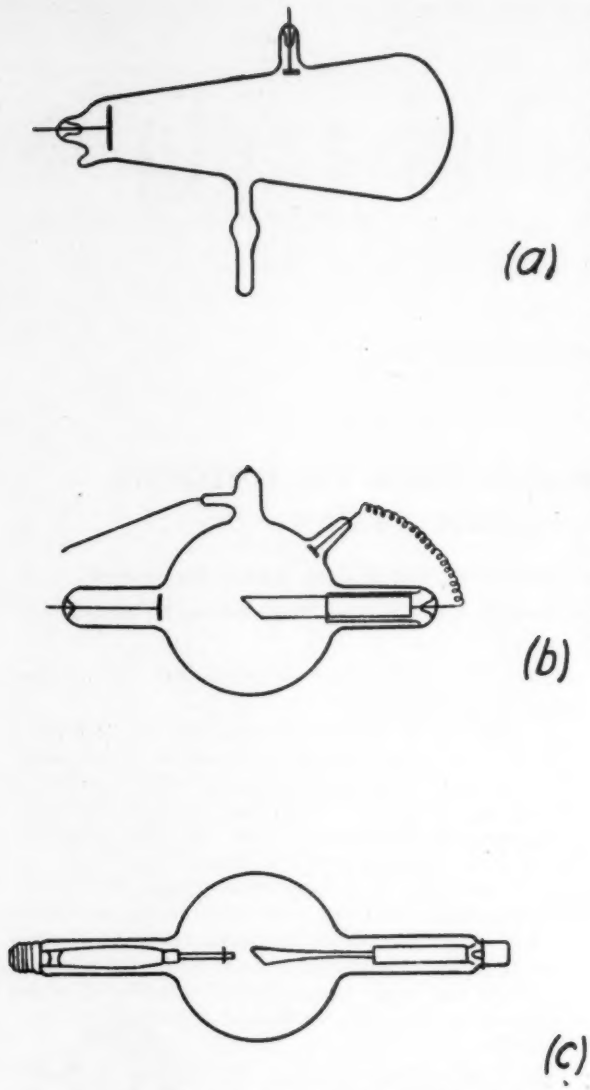


Fig. 1. Typical x-ray tubes, period from 1896 to 1935.

tically all requirements were Kovar and Nickelex (42% nickel-steel). Some tungsten lead-in wires were also used.

The Need for an All-Purpose X-Ray Glass

The problem of punctures which was intensified with the advent of the multi-section high voltage tubes in the early forties and the problems generally associated with making seals led us to an investigation in cooperation with a number of glass companies to develop an all-purpose borosilicate glass.

At the time of its development, the 7050(705AJ) type was considered to fulfill the requirements for an all-purpose x-ray glass. However, it was found that this glass had a number of faults, namely, (1) the resistivity was too high, (2) its weathering properties were somewhat poor, and (3) the vendors found it difficult to control its coefficient of expansion within reasonable limits. Of these three faults, the high resistivity was the one causing the greatest trouble. In a high voltage device such as our multi-section x-ray tube, wall charges tend to build up to such an extent that punctures result through the glass even when the dielectric strength is relatively good. In super high voltage devices such as the betatron tube, it has been found necessary to resort to application of a highly conductive coating on the surface of the glass or ceramic tube. This latter method is expensive and troublesome and we have found it unnecessary provided that the conductivity of the glass used in the x-ray tube is substantially increased.

The 7740(Pyrex brand) type glass is objectionable because of its poor match to standard sealing metals requiring the use of the 3320(Uranium) type for grading. It has approximately the same resistivity as 7050(705AJ) and cannot be tolerated where higher conductivity is necessary. The 7720(Nonex) type is of little use in the x-ray industry if for no other reason than its high lead content resulting in poor x-ray transmission.

Specifications for an All-Purpose X-Ray Glass

About 1943, in cooperation with various glass companies, concentrated efforts were made to combine the good qualities of the glasses used at that time to develop a so-called all-purpose glass for use in the x-ray industry. After much deliberation as to the desirable properties and the testing of a large number of glass batches, the following specifications were decided upon:

1. Resistivity — 6.1 to 6.5 (log of resistivity ohms/cm) at 350°C.

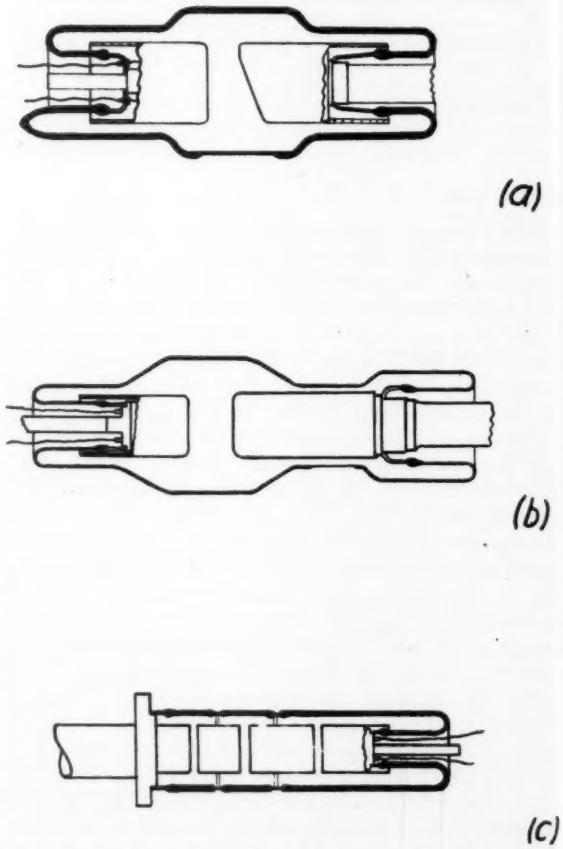


Fig. 2. Typical x-ray tubes, period from 1935 to present time.

2. Dielectric Strength (Minimum) — 80 volts/mil. at 200°C., 350 volts/mil. at 25°C.
3. Coefficient of Expansion — 47 ± 1 × 10^{-7} in/in/°C. (cm/cm/°C.).
4. X-ray transmission, x-ray deterioration, aging qualities, workability, etc., to be as good as 7050(705AJ), or 7740(Pyrex brand).

The glass companies responded with results beyond our expectations. It was surprising to us that glass could be "tailored" to meet specified properties without undue difficulties. The L650 all-purpose x-ray glass reported in this paper is manufactured by the Libbey Glass Division, Owens-Illinois Glass Company, and was the original all-purpose x-ray glass. Other glass companies have developed glasses having equivalent properties for us; 866 type by Corning Glass Works and 402 type by McKee Glass Company. All of these glasses have been used in the production of commercial x-ray tubes. Although we hope to change over our entire production to these glasses, this has not been accomplished to date for other than technical reasons.

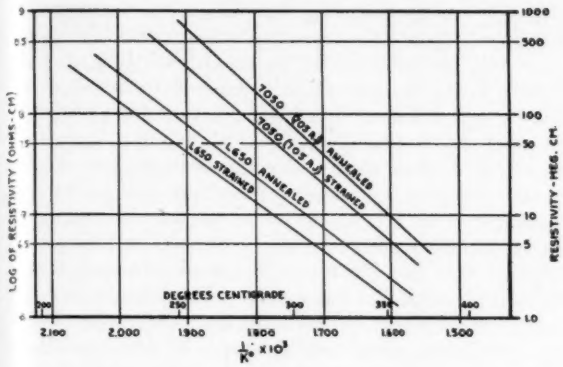


Fig. 3. Resistivity of annealed and strained 7050 (705AJ) and L650 glasses plotted against temperature.

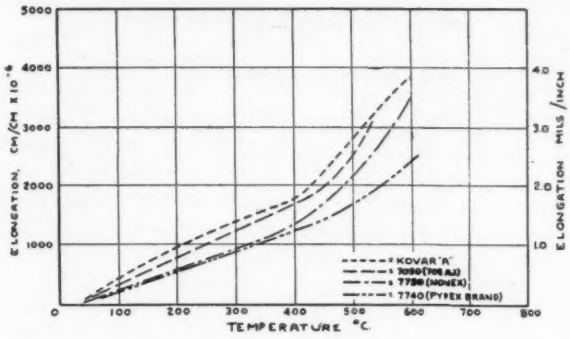


Fig. 6. Linear thermal expansion characteristics of Kovar and various glasses.

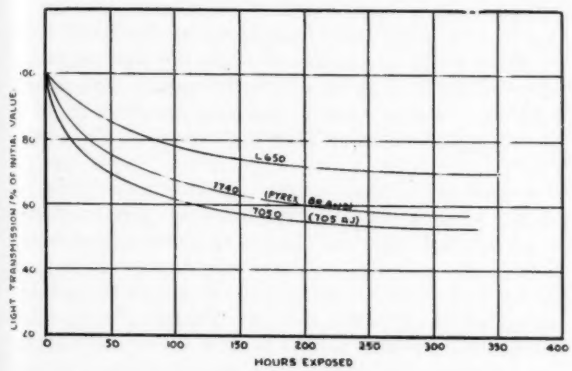


Fig. 4. Rate of discoloration of various glasses exposed to x-rays.

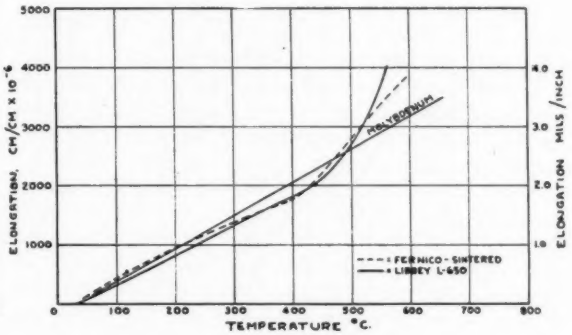


Fig. 7. Linear thermal expansion characteristics of Fernico, molybdenum, and L650 glass.

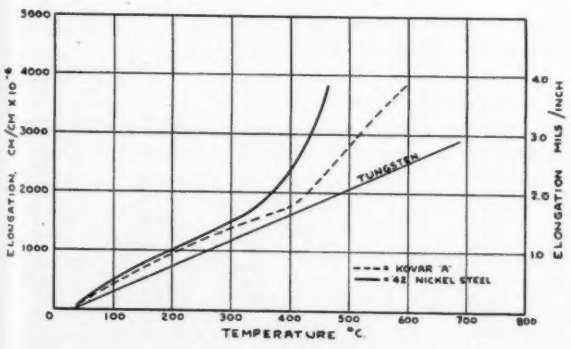


Fig. 5. Linear thermal expansion characteristics of Kovar, "42" nickel steel, and tungsten.

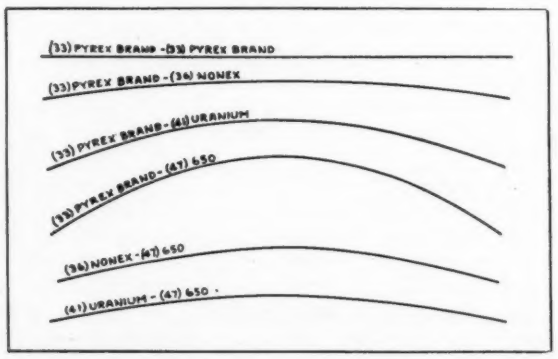

(33) PYREX BRAND - (33) PYREX BRAND
(33) PYREX BRAND - (34) NONEX
(33) PYREX BRAND - (41) URANIUM
(33) PYREX BRAND - (47) 650
(34) NONEX - (47) 650
(41) URANIUM - (47) 650

Fig. 8. Approximate curvatures assumed by various bi-glass filaments used in checking expansion values of glass.

Fig. 9. Glassworking lathe for the manufacture of multi-section and other large x-ray tubes.

Physical and Electrical Properties of Various Glasses

The most important change that was made in developing the all-purpose x-ray glass was the substantial reduction in resistivity. Figure 3 shows the resistivity of annealed and strained samples of 7050(705AJ) and L650 glasses plotted against temperature. The resistivity of 7050(705AJ) glass is approximately six times greater in value than the resistivity of L650 glass.

Percent transmission of x-rays (of commercially useful wavelengths) through 7740(Pyrex brand), 7050 (705AJ), and L650 glasses are for all practical purposes identical. The L650 glass is slightly better than 7050(705AJ) in thicknesses up to 3 mm. and slightly better than 7740(Pyrex brand) in thicknesses between 1.5 and 3.0 mm.

Glasses exposed to x-rays for prolonged periods discolor, going from a light straw-color to a deep brown. Eventually the glass shows multiple surface cracks resulting in electrical or mechanical breakdown. The mechanics of this reaction are not known but indications are that the electron bombardment actually does the damage, and the x-rays merely discolor the glass without appreciably contributing to the damage. We have found that L650 glass discolors at a slower rate than 7740 (Pyrex brand) and 7050(705AJ) glasses. The three glasses were exposed to 35 KVP copper radiation (inherent filtration —.030″ beryllium) and discoloration checked by light transmission measurements. The results of these tests are shown in Fig. 4.

Comparison of characteristics of various glasses affecting x-ray manufacture and performance is given in Table 1. The close similarity of the 7050(705AJ) and the L650 glass is quite obvious. However, recent batches of all-purpose x-ray glass are considerably higher in dielectric strength and the resistivity is generally less than 6.35.

The resistivity and dielectric breakdown tests were made according to ASTM Standards with minor deviations.

Glass sealing metals with expansion characteristics closely matching glasses used in the x-ray industry are limited in number. Actually only two such metals are generally used, excepting tungsten and molybdenum which are limited in usage to lead-in wires. The alloy consisting primarily of 29 per cent nickel, 17.5 per cent cobalt, and remainder iron (commercially obtained as Kovar and Fernico) matches the expansion characteristics of the various glasses very closely and is used as sleeves or lead-in wires where requirements are critical. An alloy consisting primarily of 42 per cent nickel and remainder iron is also used even though the expansion characteristics are not very closely matched to the various glasses. It is used because of its low cost but only where strains are below average and where sleeves can be machined very thin. It is never used for lead-in wires. The thermal expansion characteristics of these two alloys are shown in Fig. 5. Of all the glasses discussed in this paper, only the 7050(705AJ) and the L650 glasses can be sealed directly to these glass sealing metals. Both the 7720(Nonex) and 7740(Pyrex brand) glasses must be graded through 3320(Uranium) type glass because of their lower coefficients of expansion as is clearly indicated in Table 1 and Fig. 6. The thermal expansion curve of L650 glass more closely matches the nickel-cobalt-iron sealing metal than does the curve of 7050 (705AJ) glass as shown by a comparison of Fig. 6 with Fig. 7.

A very simple procedure for checking roughly the coefficient of expansion characteristics of various glasses is the "bi-glass" method. This method consists of fusing rods of the unknown sample with a known sample just enough to bond the two pieces together, care being taken not to excessively diffuse the two glasses. The resulting piece is then heated uniformly and drawn out forming a thin "bi-glass" rod. The rod is then placed on a smooth

(*Continued on page* 144)

TABLE I

Glass Characteristics Affecting X-ray Tube Manufacture and Performance

Glass Type	7050 (705AJ)	7720 (Nonex)	774 (Pyrex brand)	3320 (Uranium)	L650	866LC	402
Softening Point °C.	703	755	819	784	711	716	734
Annealing Point °C.	496	518	553	535	503	513	493
Strain Point °C.	461	484	510	497	473	483	452
Resistivity $Log_{10}R$ @ 350°C.	6.77	7.20	6.68		6.35	6.24	6.45
250°C.	8.31	8.82	8.15		7.99	7.68	7.90
Dielectric Strength Volts/Mil. 200°C.	80	80	100		80	153	209
25°C.	330	270	400		350		
Coefficient of Expansion $\times 10^{-7}$ in/in/°C.	46	36	33	40	47	48	45

THE DEVELOPING CRITICAL SHORTAGE OF ENGINEERS

By S. C. HOLLISTER, Dean

College of Engineering, Cornell University, Ithaca, New York

Our country is once again obliged to arm in an effort to preserve peace, and to prepare for attack if it should come. No thinking person fails to grasp the fact that we are greatly outnumbered and that our chances of survival are dependent upon our ability to out-design, out-develop, out-produce, and out-perform our enemies. At the same time that we are preparing for possible large-scale war, we must maintain, on a more efficient basis than ever before, our civilian functions. Moreover, we must prepare for eventual attack on our cities and on our industries and for the invasion of our homeland.

World War II brought to public attention the extent of the contribution to the war effort of the scientists and engineers. We could not have fought, much less won, that war without the vast equipment planned, developed, built, and operated by engineers. Not only have the engineers provided the country with the labor-saving devices, the means of transportation, communication, production and distribution in peacetime, but they have also provided the special versions of all these services for war. The engineers design, develop, produce, and operate the ships, the planes, the guns, missiles, rockets and ammunition, the tanks and armored vehicles, the radio, radar, sonar, loran, and other devices of communication and detection, the vast transportation facilities needed in warfare. They are clearly indispensable.

But we are short of engineers. As we advance in the war preparations the shortage will be greater. As one contemplates the dependence upon engineers in the task before us, the seriousness of a shortage in this part of our manpower becomes evident. It comes about because there has been a falling off in enrollments in engineering colleges, largely due to a widely and erroneously held belief that engineers were in over-supply. The shortage will deepen if engineers are drafted or called up as reservists and used in positions for which engineering training and experience are not mandatory.

The adjoining chart presents the essential factors in the outlook for supply of engineering graduates. The lower curve shows the annual output of the engineering colleges of the country for the academic years 1935-36 to 1950-51. It shows that from 1942 through 1945 the country, through its mistaken manpower policy, all but stopped the operation of engineering education. That is the reason why industry today is not successful in finding critically needed engineers with 5 to 10 years experience. They were not produced at the rate they should have been.

Beyond 1950 a dotted line shows the estimated number of graduates to be expected if the schools operated without any withdrawals by Selective Service. It represents the most optimistic production possible, at least until 1954, since all classes graduating up to that year are already enrolled in the colleges.

Since the number of graduates depends upon the number entering the colleges, the curve of freshmen is shown. Again is evident the low enrollment of freshmen of the war years, many of whom were taken out of college for military service. Following the war, the veteran benefits program brought the unprecedented number of 91,000 freshmen into the colleges in the fall of 1946. These did not come direct from the high school graduations in that year, but represented an accumulation of high school graduates who, for several years, had not been permitted because of the draft to proceed with college training. Since 1946 the numbers of freshmen have fallen rapidly until in 1950 there are enrolled about 30,000.

Beyond 1950 there is shown a dotted line indicating estimated freshman enrollment. This estimate was made before the Korean War, and was based on normal peacetime expectancies. It is seen that the actual enrollment for 1950 did not reach the estimate, due largely to widespread rumor that the engineering field was over-supplied.

The present situation already shows tightness in all fields, and critical shortages in many. Industry has absorbed the last two graduating classes of nearly 50,000 each and is hotly contesting for the 30,000 that will graduate in 1951. Many of the graduates are in ROTC programs and may thus go direct to military service. A large number have draft postponements and will be subject to call in June, if not before. Still others are veterans.

On August 3, 1950 the Secretary of Labor placed all branches of engineering on the list of critical occupations. In all the major branches, the shortage of engineers is becoming progressively more critical, especially in aeronautical, chemical, electrical, and mechanical manufacturing fields. Men with a few years of experience are almost unobtainable.

In normal peacetime it is generally accepted that at least 20,000 graduates are required annually. In the present situation it should be recalled that industry has absorbed 50,000 engineers in each of the last two years; but some of these certainly take the place of those that could not be hired in war years because in those years they were not being produced except in small numbers. Industry, however, does not have all it needs; and the military requirements have not as yet been taken. It thus appears that the minimum annual need is not less than 30,000 engineering graduates with use for many more if they should be available.

How do we obtain not less than 30,000 graduates yearly? First of all, to do so requires an annual input of 60,000 freshmen. This is about double the number entering engineering schools this year. How may twice as many high school graduates be attracted to engineering schools? Are there that many among the high school graduates who have an interest in engineering and who, at the same time, have the necessary aptitude and abilities?

The number of male and female high school graduates anticipated are shown at the top of the chart. It appears that between 1950 and 1958 there will be a 10% dip in the numbers graduating so that the range is between 1,250,000 and 1,130,000. We clearly cannot rely, therefore, upon an increase in output of the high schools to solve the problem.

Except for the war and immediate post-war years, which were abnormal, the numbers entering engineering

A Report to the Engineering Manpower Commission of Engineers, Joint Council, 29 West 39th Street, New York 18, N. Y., December 18, 1950.

schools since 1935 range from 2.7 to 3.1 per cent of the total high school graduating classes. On the basis of an average high school output of 1,200,000 boys and girls, 5% would be required to produce 60,000 engineering freshmen. This is about 10% of the boys graduating from high school. There is some doubt whether the combined factors of aptitude, ability, and interest would be found in so high a percentage. It seems possible that the 60,000 freshmen shown as needed on the chart may be at or above the available number that can be expected to enter engineering. This brings home the clear fact that there is not, and there cannot be developed, an inexhaustible supply of engineering talent but instead the supply is sharply limited.

Nevertheless, it is essential that all available avenues of information be used to acquaint the high school principals, high school guidance counselors, and the high school students themselves with the shortage and consequent need of engineers in all categories. It is vital to our security and welfare that such information reach these persons.

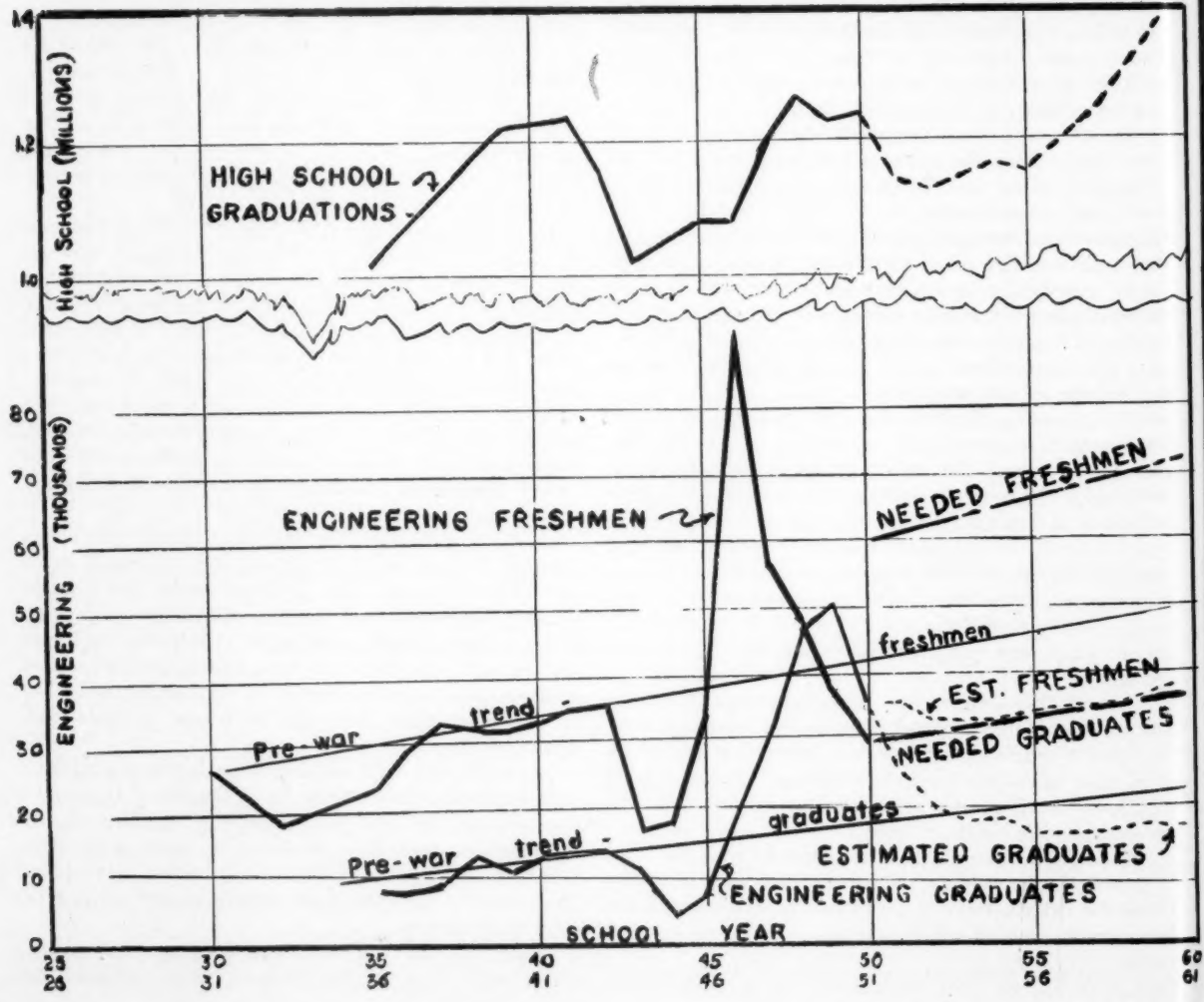
What is significant to industry in the picture here set forth? It means that there will not be young replacements for engineering jobs vacated by the calling of reservists or of draftees. There will be only a partial supply of young engineers for new jobs as conversion, re-tooling, and war production may require. Inter-company pirating will only add to the difficulties of staffing. Robbing the colleges of faculty members for industrial jobs will surely dry up the supply, and reduce the quality of training given by the colleges.

It will be essential for industry to re-examine the functions of the engineering personnel and to make certain that each engineer is being used in the most effective manner possible. No engineer should be used in positions others can occupy as well. Supporting personnel, requiring less training and experience, should be used to spread as far as possible the effectiveness of each engineer.

Even competent supporting personnel will be tight. It will be necessary to begin in-service training of such personnel, and to engage women as far as possible. The training programs of the last war will need to be re-established. None of these steps can be put off. The organization of industries must be streamlined now.

(*Continued on page* 144)

Outlook for engineering graduates. Actual and estimated enrollment by U. S. Office of Education. Needed freshman and graduates estimated by S. C. Hollister. (To accompany article "The Developing Critical Shortage of Engineers," by S. C. Hollister.)



THE NATURE OF THE VITREOUS STATE

By IVAN PEYCHES, Director of Research
St. Gobain Glass Works, Paris, France

TRANSLATED FROM SILICATES INDUSTRIELS, 1950
By F. W. PRESTON

PART III

The study of the properties of glass in its high-temperature states presents considerable experimental difficulties. Measurements of refractive index, thermal expansion, or density, cannot be carried out at 1,000 or 1,500°C. with the necessary precision. Mechanical constants, in particular Young's modulus, have no meaning any longer in the molten state. The only things which avoid these difficulties, by reason of their enormous variation with temperature, are the viscosity and electrical conductivity. Experimentalists who have attacked the earlier-mentioned properties have attempted to stereotype the high-temperature state by "freezing it in" very rapidly and then studying at leisure, in the cold state, what they postulate they have captured. From a strictly logical point of view, the method lacks rigor and its only extenuation is that it is convenient. It may lead to dangerous misinterpretations. We may show this by an example. Gillod, studying Young's modulus, carried out the following experiment:

Small rods of glass are maintained for different lengths of time, t, at a given temperature, θ. For each time of soaking, one rod is suddenly chilled and its Young's modulus measured. The curve of E_θ (Young's modulus for the particular soaking temperature), plotted as a function of the time of soaking, f(t), permits a determination of the asymptotic value of the modulus for the temperature in question. The experiment is repeated for various other temperatures. The curve $E = \phi(\theta)$ then shows a plateau at the level of $E_1 = 8.473$ kg. per sq. mm., in the case of the glass studied by Gillod, as far as $\theta_1 = 575$°C., then drops steadily to a new plateau level $E_2 = 7.684$ kg. per sq. mm., from temperatures of $\theta_2 = 700$°C. onwards. Gillod thinks he can conclude, in the light of the theories of Madam Winter-Klein, that there exists a state α defined by the modulus E_1, and stable below θ_1, and a state β characterized by the modulus E_2 and stable above θ_2, while in the temperature range between θ_1 and θ_2 is a transformation range in which α inverts to β and vice versa.

This explanation is not the only one possible. It would be sufficient to postulate structural changes virtually instantaneous above temperature θ_2, under the experimental conditions that were used, and that these changes are absolutely blocked below temperature θ_1, still referring only to actual experimental conditions in order to explain the facts. This amounts to saying that the structural state which follows the temperature in the process of "stereotyping" does so in the first instant without delay, then undergoes a lag of greater and greater amount, and that finally this lag becomes infinite.

Under these conditions, whatever may be the high temperature from which we start, provided only that it be above θ_2, what is measured in the cold state is the value of the property at a stage where it has no longer been able instantaneously to follow the course of the chilling; and that whatever the low temperature may be at the start, providing only it is below θ_1, what is measured is the optimum value acquired at the stage where the lag has become virtually infinite in comparison with the duration of the experiment.

This interpretation postulates that the structural state can follow instantly variations which take place at high temperature and hence is in contradiction with the hypotheses of Section II hereof. But the structural state might quite well come out differently according to what physical property is being studied. Viscosity will interpret primarly the bonding and slipping of the frame-work elements Si-O, while thermal expansion would indicate primarily the average distances between the constituent elements of the frame-work, and the electrical conductivity would indicate the mobility of the alkaline ions in the interstices of the frame-work, and so on.

It would be too primitive a way of thinking to expect that all properties must commence, and cease, to vary simultaneously. A careful study of these properties carried out, for instance, by the experimental technique of Gillod and, of course, carried out upon the same identical glass, would necessarily lead us to postulate a different equilibrium in the α to β inversions for every class of physical properties. By way of analogy we may recall the dissociation theory of Arrhenius which led to "anomalies" among strong electrolytes whose degree of dissociation varies according to the property studied, a theory which was later completed by the more satisfactory theory of "ionic atmospheres" of Debye and Huckel.

A simple comparison of the work of Gillod on Young's modulus and on density, which does not involve "stereotyping", promptly shows a substantial difference of the transformation range in which α goes to β.

The principle of stereotyping must therefore be used with circumspection and its results scrutinized with some skepticism.

On the other hand, studying the properties of a glass that has been violently chilled involves superposing upon the structural effects properly so-called, other effects purely mechanical in nature due to the fact that different zones of the glass pass at different times through the critical temperatures. Adams has clearly demonstrated that variations in density produced by mechanical forces are negligible in comparison with the variations of density of a structural origin. But this would not necessarily be the case, for instance, for surface conductivity, chemical reactivity, and so on. It would be convenient, therefore, if a clear-cut separation could be made of the effects.

Acloque, at the laboratories of the St. Gobain Glass Works, was able to obtain states of stress inverted with respect to a normal quenching, that is to say, specimens showing in their outer layers a tension and in the inner

ones a compression, whereas in the two cases of normal quenching or inverted quenching, the surface structure corresponds to one of higher temperature than that of the interior. Here then is a method which ought to permit a separation of the two effects. But one comment may be made here which may equally well permit us to separate these effects in a fashion more immediately accessible to experiment.

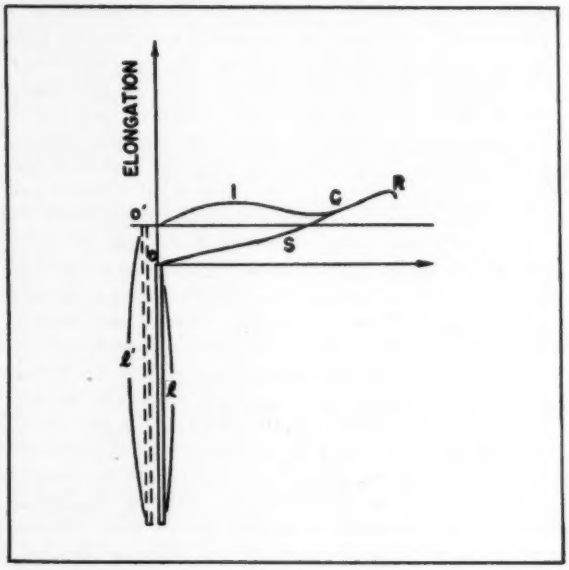
The laws of cooling of a flat plate are sufficiently well known in a number of particular instances. Glass complicates things a little because these laws assume that the transfer of heat from the interior to the surface of the plate is fundamentally a matter of conduction, whereas we have to deal with a semi-transparent substance. Nevertheless the time factor always comes in in the form of the exponential $e^{\frac{-t}{\tau}}$. Here τ is a constant equal to $a^2/\pi^2 h$, where a is the thickness of the plate, h is the diffusivity K/γ, a quantity substantially constant over the interval of temperature under consideration. Hence we conclude that a given state of chilling is attained in a time which varies inversely as the square of the thickness. On the other hand, a given system of mechanical stresses should become established over a constant number of molecular layers independently of the total thickness. It can be shown that the temperature gradient over a constant interval of thickness diminishes when the total thickness diminishes.

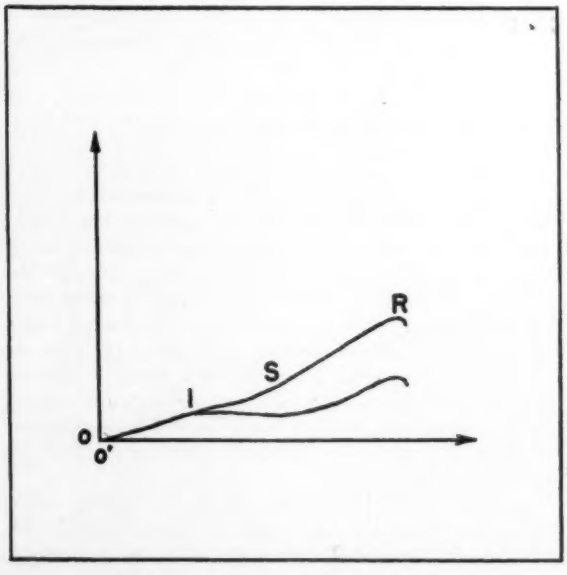
Hence, as we examine thinner and thinner sheets of glass, or more generally more and more minute volumes, we increase the chances of freezing in a given structural state and diminish the chances of superposing a state of mechanical strain. Thin bulbs and fibers of glass should lend themselves particularly well to interpreting these points.

We have used as our experimental material expansion measurements made at the laboratories of the St. Gobain Glass Works by Meyer, Bourgeaux, and Betoin.

Let us take an idealized expansion curve.

A well-annealed rod, which in the cold state has a length l, follows, as the temperature is raised, the curve OSR. The point S is usually described as the transformation point, and R is the softening point under the experimental conditions. If, from a point near to but ahead of R, we suddenly chill the specimen, we obtain a quenched sample whose length, l′, is greater than l, it is true, but is never in any case greater than the absolute ordinate of the point R. If we now make a new expansion test upon this quenched specimen, we obtain a curve O′I substantially parallel to OS, indicating the fact that the same expansion coefficient applies to a length which is very slightly different; then follows a curve of adjustment IC* indicating the fact that at these temperatures the chilled state, whatever may be its exact nature, changes towards the original state, and finally we get a section of curve CR indistinguishable from the tail of the original curve SR, indicating the fact that at this temperature there is no longer any difference between the specimen which was initially quenched and the annealed specimen. At no





Top, Fig. 2a; Bottom, Fig. 2b.

* IC may join the "annealed" curve below S. The junction point depends on the size of the specimen and the rapidity of the test, etc.

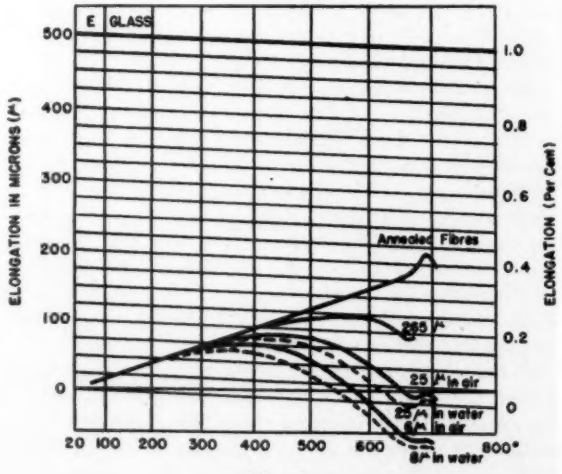


Fig. 3.

point will this new curve have an ordinate greater than that of the point R, so long as the expansion test is sufficiently slow to avoid any substantial lag between properties and temperature. Using the older types of expansion apparatus, the absolute length of the specimen is not determined, and the ordinates O and O′ are confused. This results in the curve of Figure 2b.

The curve for the quenched specimen at temperatures equal to or below R cannot pass below the axis of X.

Consequently, if an expansion-test curve does pass below the X-axis, this would indicate that the specimen studied was "frozen" in a state corresponding to a temperature higher than corresponds to the softening point.

Now, in the process of drawing a glass fiber which leaves the bushing at a temperature of 1200°C., the natural chilling is extremely rapid. Betoin increased this chilling by "icing" the fiber with a film of water immediately it left the bushing. He states that this quench produced by the water is less effective in proportion as the fiber is finer and in consequence naturally cools rapidly. We must conclude, then, that for the finest fibers the mere process of drawing is sufficient to give the specimen a very severe quench.

Taking then a glass known as E glass, having substantially this composition:

SiO_2	55
B_2O_3	9.3
Al_2O_3	15
CaO	14.5
MgO	4.5
Na_2O	0.7
Misc.	1

we may state henceforward that specimens drawn in the ordinary fashion from a constant initial temperature around 1,200°C. give a curve which lies lower in proportion as the diameter of the specimen is smaller. See Figure 3.

These experiments were carried out on rods of 8 mm. diameter, filaments of 265 microns, 25 microns and 8 microns diameter, and on industrial glass fibers known as continuous textile fibers (Silionnes) of 5 to 6 microns. Beyond 25 microns the curves pass below the X-axis. In every case a re-annealing causes the curves to rise to the values characteristic of glass annealed in the massive state.*

Before attempting to place an interpretation on the negative values of the elongation, we wanted to check that these values really were acquired above the softening point. To find an answer to this question, fibers of 25 microns diameter were held for a long time in the immediate neighborhood of the softening point and suddenly quenched in a water bath. It may be thought that this would freeze in a state not very different from that which would be stable at the softening point, and in a condition more active than that of a simple air-quench which, beginning at a high temperature, would not really take effect until we passed below 700°C.

The expansion curve is given in Figure 4. *The effect is distinctly less pronounced.* However, we may note in passing that expansion anomalies might have been interpreted as coming from a special structure due to the drawing operation, for example, an orientation in the longitudinal direction. The fact that this orientation has certainly been destroyed by heating to the softening point, since the fibers thus reheated give an expansion curve identical with that of massive glass, and that the anomaly persists in part at any rate as a result of a single quench from the softening point, excludes the possibility that these anomalies are primarily due to a structural state arising from the drawing process itself.

In order to verify the absence of a special structure due to the tensile stresses exerted in the course of drawing the fiber, we produced some threads of 230 microns diameter from an orifice at a temperature of 830°C. by extruding them under a pressure of 7 kg. per sq. cm.

Then, starting from the same temperature, threads were drawn at substantially the same speed as that of the preceding extrusion process and with substantially the same diameter. The cooling conditions were the same, but in the one case there was a pressure tending to tighten up the network and in the other a tension tending to stretch it. In both cases the expansion curves are identical. Expansion, therefore, does not permit us to distinguish a possible variation in energy levels. It is

* It may be noted that the agreement of temperatures S and R for the various specimens emphasizes that the variations are not due to defective experimental technique. This latter will be explained elsewhere.

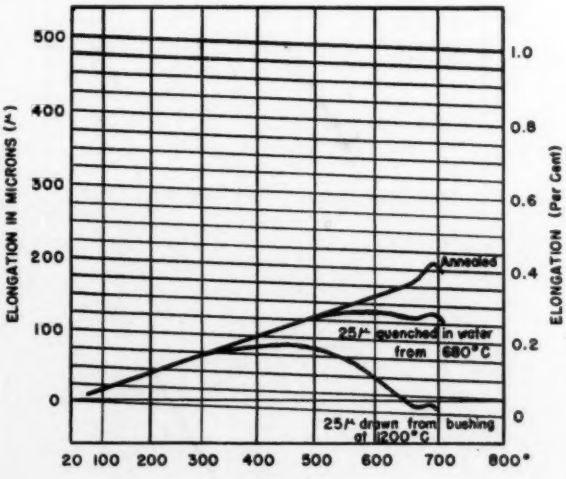


Fig. 4.

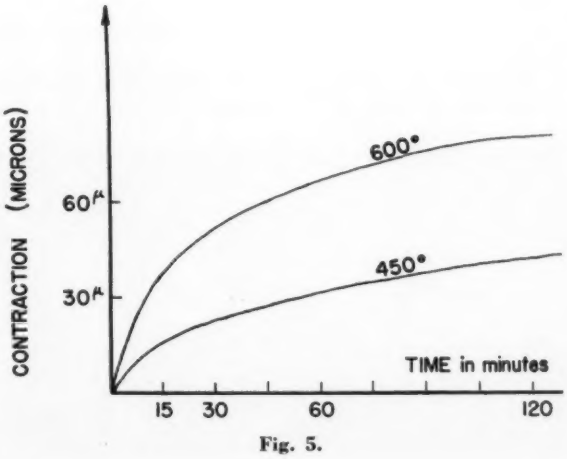


Fig. 5.

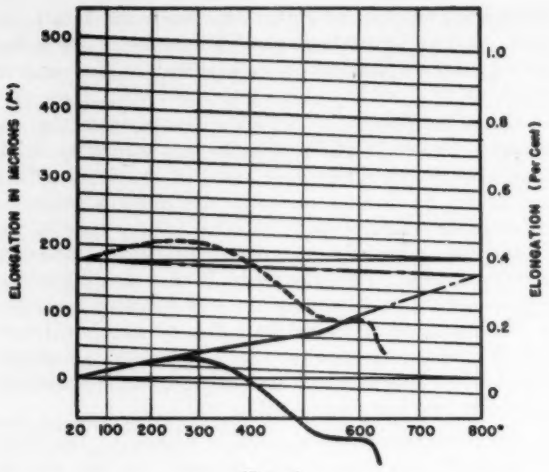


Fig. 6.

true, of course, that the experiment could only be carried out on rather coarse fibers, and we have seen previously that the freezing-in process is not very effective on diameters of this order. It is conceivable that an initial difference may have been eliminated before actual "freezing-in" took place.

We postulated in the second section of this paper that a change was still possible at low temperatures, with a speed not negligible on a human scale. However, if we direct our attention to point I in Figure 3, we note that this point, which is normally considered as the first indication of a loosening up of the bonds (the lower limit of annealing or the strain point) and which can be varied within somewhat narrow limits as a result of changing the speed of testing, here varies in an unaccustomed fashion. Whereas this point is above 450°C. for massive glass and for fibers of 265 microns, it drops to 250°C. for fibers of 6 microns diameter.

These points can furthermore be modified by the speed at which the temperature is raised in the expansion test. The speed we used was 2°C. per minute. This speed is far from permitting equilibrium to be attained. If the "textile" fibers kept for 2 hours at 225°C. do not show at the end of this time any appreciable change, they do, on the other hand, when maintained for 2 hours at 450°C., show a contraction which continues after the rise in temperature has been stopped. See Figure 5. In spite of the tendency of the curve to approach some asymptotic value, the limit is far from being reached after 2 hours.

If the rise in temperature is sufficiently slow, we ought to succeed in lowering still further the point I. For the borosilicate glass M 184 shown in Figure 7, the point I descends within the range of room temperatures.

We may now seek to attach a meaning to negative elongations. Let us consider the expansion curves of a fiber of Pyrex glass, 18 microns in diameter, drawn in the normal fashion and then either quenched (T) or re-annealed (R). See Figure 6.

If we shift the height of curve T so as to make the tail end of the curve adjoining the softening point coincide with the curve R, we obtain the upper part of the figure (O'R). The point O' has a higher ordinate than that of the softening point. The fiber which furnished curve T comes therefore from a state situated above the softening point, along the dash-dot line which prolongs the curve R. We know furthermore that the slope of the curve above the transformation point can only diminish, for otherwise it would lead to too low densities at high temperatures. In choosing to extrapolate the portion of the curve of maximum slope, therefore, we are putting ourselves in the least favorable situation to detect evidence of a high temperature structure.

Similarly the part of the curve O'I represents the strictly "solid" expansion, due to the anharmonic vibrations of the quenched psuedo-lattice (reversible expansion). Once more we are again placing ourselves in the most unfavorable situation in postulating that the point O' represents the end of the fiber just as it was quenched from the supposed high temperature. Projecting O' on the prolongation of curve R, we obtain the abscissa of some temperature θ_0 which is certainly a lower limit of the temperature zone from which the specimen T has been "frozen in". What is important is that we thus demonstrate the possibility of observing a frozen-in state which is unequivocally above the softening point. This phenomenon is observable with all glasses. As an example, we give in Figure 7 the curves relating to a borosilicate known as M 184, annealed, quenched in the mass from 700°C. and drawn from a bushing at 1,200°C. The point I comes within the range of room temperatures as previously mentioned.*

Consequently when one works with extremely small volumes of glass, in the special state resulting from extremely rapid freezing from very high temperatures, it is possible to demonstrate changes at exceptionally low temperatures.

In conclusion, we may say therefore that these preliminary experiments are consistent with what we should expect from the hypotheses of Section II. Changes can take place at low temperatures. Frozen states correspond-

(*Continued on page* 142)

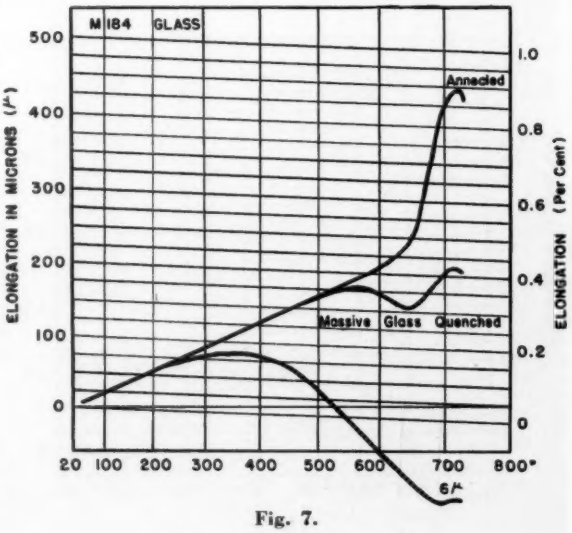


Fig. 7.

* We may note in passing that we have attempted, by the study of fine fibers, to separate as best we may mechanical effects from structural ones. Nonetheless, Bourgeaux and Meyer have shown that fibers of 265 microns and 25 microns diameter, when cut along a plane parallel to the axis, show a pronounced birefringence. There therefore exist in these fibers mechanical strains characterized by a surface compression and a tension in the interior. The significance of this birefringence will be discussed elsewhere. (Note added by translator: This matter is still *sub judice*, some American experimenters having failed to duplicate the result.)

CORNING'S GLASS CENTER TO OPEN THIS SUMMER

Corning, New York, will become this summer the home of a Glass Center dedicated to the history, art, science, and industry of glassmaking and embracing a new Steuben factory, and a museum and library to afford the most comprehensive facilities in the world for research and education in glass.

The project, understood to involve a cost of about $2,500,000, has been under construction since the late summer of 1950 and is scheduled to open toward the middle of the centennial year of Corning Glass Works, its sponsor.

Plans were announced, with elaborate descriptive panels, before an audience of 250 editors and writers in the Waldorf-Astoria Hotel on February 5. Details were related by Amory Houghton, Chairman of the Board of Corning Glass Works; Arthur A. Houghton, Jr., President of Steuben Glass, Inc.; and Wallace K. Harrison, of the New York firm of architects, Harrison and Abramovitz, prominently associated with Rockefeller Center and the United Nations buildings.

Arthur A. Houghton, Jr., (left) President of Steuben Glass, Inc.; Amory Houghton (center), Chairman of the Board of Corning Glass Works; and Wallace K. Harrison, the architect, discuss a blueprint and model of the Corning Glass Center.

Instead of commemorating its hundredth year with events emphasizing the company's achievements in the past century, the spokesmen for Corning Glass Works stated that its efforts are directed toward the needs of the future, by the facilities of the Glass Center.

A novel phase of the enterprise will be the production of Steuben ware before the eyes of visitors. The nature of glass manufacture usually forbids the close presence of outsiders. But in this instance, in recognition of the vast number of requests received for permission to view the fascinating process of glassmaking, the new Steuben plant will be provided with spectator galleries. These will afford a close inspection of all production operations in making fine hand-blown glass, from furnace to lehr.

Convertible to Defense Uses

It was stated at the meeting that, if needed, the new Steuben factory will be readily convertible to defense purposes. As soon as the new plant is in operation, the present Steuben furnaces, in one of Corning's many buildings, will be turned over to other production.

The Glass Center is on a seven-acre site within the city of Corning, fronting 693 feet and reaching a 504-foot depth. It is on well-traveled north-south and east-west highways near the junction of Routes 17 and 414. It is served by the main lines of the Lackawanna and Erie railroads and has New York Central freight facilities. Twelve miles away is the Elmira Corning Airport. Easily accessible is the Finger Lake vacation region. Thus, while the Library and Museum are expected to attract many students, scientists, historians, and others engaged in glass research, the location of the Glass Center, its sponsors believe, will also draw large numbers of the public.

The two-story Corning Glass Center will have over 100,000 square feet of floor space. It will include, in addition to the Steuben plant, the Library, and the Museum, a number of study and lecture rooms, a 2,000-seat auditorium for company and community purposes, and facilities for employee activities.

200-Inch Disc on View

Immediately on entering the main lobby, dimly lighted and thickly carpeted, the visitor will find the accent placed on the first great 200-inch telescope disc, over 17 feet high and weighing over 20 tons, cast by Corning Glass Works, as was the disc of similar proportions now

(*Continued on page* 146)

Left to Right: Thomas G. Buechner, Director of the Museum of Glass; E. P. H. James, Director of Public Relations, Glass Center; Dudley Olcott, Business Manager, Glass Center; Rushmore H. Mariner, who is in charge of the development of the Glass Center; and James M. Brown, 3rd, Director of the Glass Center.

STANDARDIZATION OF IRON-CONSTANTAN THERMOCOUPLE TABLES

National Bureau of Standards, U. S. Department of Commerce, Washington 25, D. C.

The iron-constantan thermocouple is widely used in industry for measurement of temperatures up to 1500°F. Yet it is the only type of thermocouple for which uniformity of commercial practice has not been established in this country. Recently, at the request of the Scientific Apparatus Makers of America, the National Bureau of Standards has undertaken to derive a temperature-emf reference table for iron-constantan thermocouples which would be suitable for adoption as a standard.

The temperature-emf tables for thermocouples which the Bureau has issued from time to time have been used extensively in science and industry, not only to convert thermocouple voltages into the equivalent measured temperatures but also in the preparation of purchase specifications for thermocouple wire and in defining the relation between impressed emf and scale reading for pyrometers which indicate temperature directly. In practice the calibration of an individual thermocouple is ordinarily given in terms of deviations from such a reference table. Since it is usually not convenient to change the scale of a direct-reading pyrometer to compensate for variations in the thermocouples which may be used with it, thermocouples are commonly purchased under specifications which ensure that they will correspond closely to the graduation of the particular model of pyrometer used.

Some time ago, an investigation[1] of iron-constantan thermocouples by the Bureau disclosed that the thermocouples of this type which were then commercially available did not follow closely any of the several temperature-emf relations for iron-constantan in use by pyrometer manufacturers. The Bureau therefore derived a new table, usually known as the RP 1080 table, which represented the average behavior of the iron-constantan thermocouples on the market. However, rather than alter the scales of their pyrometers to conform to the actual properties of the thermocouples then being sold, most of the various manufacturers made efforts to develop and make available thermocouples which would correspond to the temperature-emf table they were using. As a result, a number of widely diverse reference tables for iron-constantan thermocouples are still in use.

In an effort to achieve greater uniformity, the Recorder-Controller Section of the Scientific Apparatus Makers of America, representing several of the pyrometer manufacturers, in 1948 adopted the temperature-emf relation known as the 1913 (L and N) table[2] as a tentative standard for iron-constantan thermocouples over the range from 32° to 1400°F. This relation was chosen because it is in wider use than any other. However, experience has shown that it is apparently not possible to produce a thermocouple which will correspond precisely to the 1913 table over the entire range from 32° to 1400°F. Moreover, any thermocouple which closely matches this table in the range below 1400°F. will deviate greatly from it in the range above 1400°F. The SAMA therefore requested the National Bureau of Standards to derive a reference table which would be free from these defects. It was felt that such a table should be as close to the 1913 table as possible, yet should represent the properties of an actual commercially available thermocouple.

Eight different lots of matched iron and constantan wires were submitted to the Bureau by four members of SAMA. The thermal emf's of the various wires versus platinum were measured in the Bureau's pyrometry laboratory from 32° to 1800°F. From these data, the corresponding thermal emf's for the iron-constantan thermocouples were computed. In addition, chemical and spectrographic analyses of the iron samples and hardness determinations were made. It was found that the spread in the thermal emf's of the iron-constantan thermocouples below 1400°F. was not large compared to usual commercial tolerances, even though the iron samples differed among themselves by as much as 0.8 millivolt at 1400°F. (equivalent to about 20 degrees in the indication of an iron-constantan thermocouple) and the constantan samples differed similarly. Present preference is to base the new SAMA table upon the temperature-emf relation of thermocouple A-1, since this thermocouple deviates least from the 1913 table in the range of normal use.

The question may now be raised whether the field of use of this proposed new table can be broadened through industry-wide acceptance. Support by this Bureau for any new table (taking the form of official publication and possibly resulting in inclusion in a Federal Specification) might conceivably cause hardship to suppliers and users of iron-constantan thermocouples who have based their operations on the RP 1080 table. Thus, it is felt that the views of all interested parties should be obtained as a prerequisite to the adoption of this table. The questions that naturally occur if the proposed table can be adopted are the following: Is industry-wide standardization on a single reference table for iron-constantan desirable? Is the 1913 table, or a close approximation to it, acceptable for this purpose? What degree of hardship will be occasioned by abandonment of the RP 1080 table? The reaction of producers and users of pyrometers is a matter of interest to the Bureau, and replies to the above questions as well as related comments can be addressed to the National Bureau of Standards, Temperature Measurements Section, Washington 25, D. C.

[1] Reference tables for iron-constantan and copper-constantan thermocouples, William F. Roeser and Andrew I. Dahl, J. Research NBS *20*, 537 (1938) RP 1080.

[2] Identical with the tables given in International Critical Tables *1*, 59 (1926) and in Tech, Pap. BS *14*, 306 (1920-21) T170, Table IV, Col. L.

NEW OPTICAL SUBSIDIARY FORMED

The formation of a new subsidiary company, the Pacific Optical Corporation, has been announced by Robert P. McCulloch, President of McCulloch Motors Corporation, manufacturers of gasoline-engine products. The new company occupies buildings and facilities formerly operated by Del Riccio Plastic Products Corporation.

According to Mr. McCulloch's announcement, the Pacific Optical Corporation provides a quantity source on the West Coast for glass or plastic lenses and prisms and other optical products. Acquisition of the new subsidiary marks the entry of the young McCulloch organization into an entirely new field.

Inventions and Inventors

Annealing

Method of Annealing. Patent No. 2,539,159. Filed Feb. 26, 1944. Issued Jan. 23, 1951. One sheet of drawings, none reproduced. Assigned to Hartford-Empire Company by Karl E. Peiler.

This patent states that glassware is damaged by hitting together at the packing table due to the fact that the inside temperature of the ware is higher than the outside. Such damage is prevented by raising the outside temperature close to that of the inside. This is done by passing the ware through a heating oven located perhaps half way between the end of the lehr tunnel and the end of the packing table. This removes the strain set up by the difference in temperature and thus prevents injury to the ware in handling at the packing table.

The patent contains four claims and 12 references were cited by the Patent Office.

Feeding and Forming

Lip Forming Machine. Fig. 1. Patent No. 2,538,533. Filed March 27, 1948. Issued Jan. 16, 1951. Five sheets of drawings. Assigned to Chamberlain, Inc., Chicago, Ill., by Andrew Paterson.

The container 30, having been formed without a lip or a pouring spout, is heated at the point 29 where the lip is to be made by a burner 44. Rolls 34 and 35 are turned by the shafts 16 and 18 and these act to raise and lower a rod 27 having a lip forming end 28. Connections to a shaft 11 advance and retract the rod. The container is held on a base by suction and as soon as the glass has been softened the mechanism is thrown into operation to cause the lip forming tool to form the lip.

The patent contains 10 claims and the references cited were 193,317, Buttlear, July 24, 1877; 1,546,353, Rippl et al., July 14, 1925; 1,578,427, Gray et al., Mar. 30, 1926; 2,151,840, Dichter, Mar. 28, 1939; 2,366,609, Gates, Jan. 2, 1945; and 2,377,534, Wexell et al., June 5, 1945.

Machine for Making Lamp Bases. Fig. 2. Patent No. 2,538,589. Filed June 28, 1946. Issued Jan. 16, 1951. One sheet of drawings. Assigned to General Electric Company by Stanley Poje.

The machine shown in the drawing is of the same general type as shown in Patents No. 1,210,237 and 1,210,238 to Walker et al, having 36 molds mounted on a turret. The molds 1 hold the metal shells 3 and the eyelet 4 to be incorporated in the base. The bottom of the mold is formed by a vertically movable plunger 12. A continuously flowing stream of glass 18 goes into each mold during a dwell in the movement of the turret leaving a string of glass 19 between the molds. If these strings do not break off by gravity, they are severed by cutters 23 and 24 located at two stations. At a later station a plunger forms the glass in the bottom of the shell. Means is provided to remove the severed strings 19 at a later station.

The patent contains four claims and the references cited were 796,470, Swan, Aug. 8, 1905; 2,116,450, Richardson et al., May 3, 1938; and 2,315,292, Richardson et al., Mar. 30, 1943.

Mold. Patent No. 2,538,822. Filed Aug. 24, 1946. Issued Jan. 23, 1951. Two sheets of drawings, none reproduced. This is an invention by Samuel E. Winder who assigned one half interest to Henry C. Daubenspeck.

The object of the invention is to provide a mold carrier on which the molds may be readily removed and replaced and which will close the molds securely even when they are somewhat warped. Mechanism is provided for adjusting the molds vertically and otherwise.

The patent contains 11 claims and the references cited were 1,856,577, McLaughlin, May 3, 1932; 1,974,841, Allen, Sept. 25, 1934; 2,018,785, Harrison, Oct. 29, 1935; 2,161,255, Howard, June 6, 1939; 2,307,563, Bridges, Jan. 5, 1943; and 2,378,176, Bert, June 12, 1945.

Suction Machine Mold. Fig. 3. Patent No. 2,539,114. Filed (original) Apr. 17, 1943. Issued Jan. 23, 1951. One sheet of drawings. Assigned to Owens-Illinois Glass Company by George R. Bowe, Jr. This application was divided from one resulting in Patent No. 2,425,592 dated Aug. 12, 1947.

The suction mold shown in the patent is of about the usual construction except that the glass engaging surface is provided with an annular recess so that a ring 26 on the glass surface is not in contact with any part of the mold and, therefore, the ring is not chilled. This causes

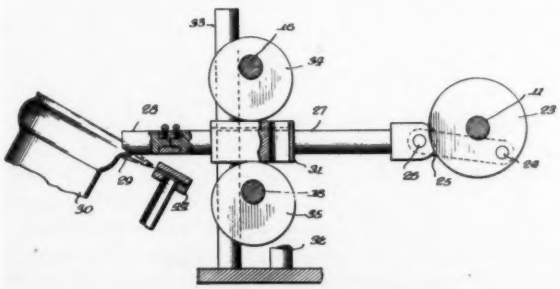


Fig. 1. Lip Forming Machine.

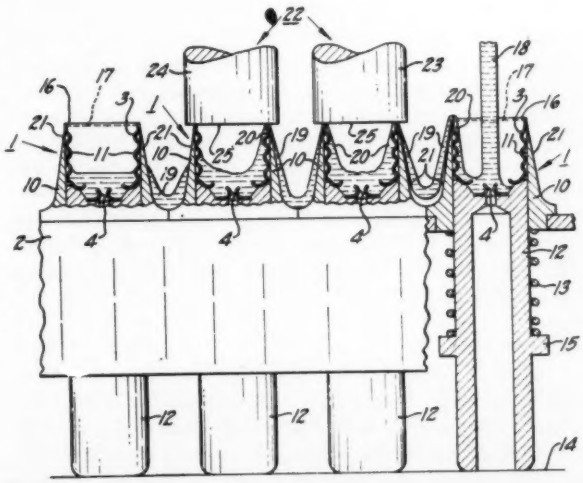


Fig. 2. Machine for Making Lamp Bases.

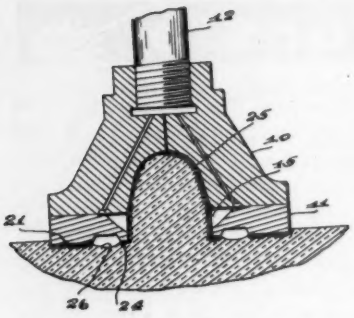


Fig. 3. Suction Machine Mold.

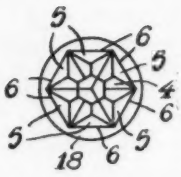


Fig. 4. Mold for Reflectors.

the glass connecting the mold, and that in the pool, to neck out and permit the shears to cut the neck with little or no shear scar.

The patent contains eight claims and the references cited were 1,223,392, Kadow, Apr. 24, 1917; 1,807,095, Treece, May 26, 1931; and 1,986,449, Schutz, Jan. 1, 1935.

Mold for Reflectors. Fig. 4. Patent No. 2,538,638. Filed Oct. 1, 1946. Issued Jan. 16, 1951. This is an invention by Herbert F. Wilson, Wembley, England.

A simple form of the invention is shown in the figure where the central reflector 4 is surrounded by six reflectors 5 which form a hexagonal outline. The patent relates mostly to the particular form of the reflector elements and their assembly. It is not of great interest to the general line of glass forming.

The patent contains three claims and eight references were cited.

Forehearth Temperature Control. Patent No. 2,539,145. Filed Oct. 1, 1946. Issued Jan. 23, 1951. Three sheets of drawings, none reproduced. Assigned to Hartford-Empire Company by John S. Light.

The object of this invention is to maintain the temperature of gobs delivered from a glass feeder. A thermocouple is located toward the tank end of the forehearth and one or more thermocouples are located near the spout. Another thermocouple is located near the orifice in the spout.

Automatic controls are provided to maintain the glass temperature at a constant desired point at the thermocouple near the tank. The difference between the temperature near the tank and that near the orifice acts automatically to regulate the heat between these points so as to maintain a uniform temperature of the issuing glass. The patent gives full disclosure of the various automatic mechanisms employed.

There are three claims in the patent and the references cited were 1,961,894, Wadman et al., June 5, 1934; 2,098,625, Honiss, Nov. 9, 1937; and 2,153,922, Green et al., Apr. 11, 1939.

Furnaces

Glass Melting Pot. Fig. 5. Patent No. 2,541,310. Filed Aug. 24, 1949. Issued Feb. 13, 1951. One sheet of drawings. Inventor, Franz Uhrmann, Muhldorf am Inn, Germany.

The patent calls this invention a "melting Kettle", which in this country is called a pot. The invention consists of an annular collecting rim 10 which catches the overflow from the pot. This, in turn, is discharged into a collecting pot 14 from which it may be returned by a ladle 19.

The patent contains five claims and the references cited were 1,564,235, Harrington, Dec. 8, 1925 and 109,423, Germany, Nov. 26, 1898.

Glass Compositions

Enamel Opacifier. Patent No. 2,537,955. Filed Dec. 14, 1946. Issued Jan. 16, 1951. No drawings. Assigned to National Lead Company by William J. Baldwin.

The invention relates to a mill addition opacifier, particularly for use with zirconium opacified frits which develop opacity on heating in the enameling cycle.

The first of the two claims of the patent is as follows: The method of increasing the opacity of an enamel frit composition of the zirconium opacified type wherein the opacity is developed in the enameling cycle which comprises adding to the enamel as a mill addition opacifier 2 to 4% by weight of a finely ground calcined material containing 50 to 75% aluminum oxide and 50 to 25% phosphorus pentoxide as the essential ingredients.

The only reference cited was Blumenberg No. 1,654,404 dated Dec. 27, 1927.

Enamel Opacifier. Patent No. 2,537,956. Filed Dec. 31, 1946. Issued Jan. 16, 1951. No drawings. Assigned to National Lead Company by William J. Baldwin.

This patent is very similar to the preceding and is by the same inventor. It contains four claims, Claim 1 being: The method of increasing the opacity of an enamel composition containing combined zirconium wherein the opacity is developed on heating in the enameling cycle, which comprises adding 2 to 4% of a calcined product containing Al_2O_3, P_2O_5 and Sb_2O_3 as the essential ingredients and in amounts corresponding essentially to the empirical formula $3Al_2O_3.P_2O_5.Sb_2O_3$, to the enamel composition as a mill addition opacifier and heating to an enamel-forming temperature of 1520°C.

The references cited were 2,199,794, Harshaw, May 7, 1940; 2,252,588, Whitesell, Aug. 12, 1941; and 2,347,187, Frost, Apr. 25, 1944.

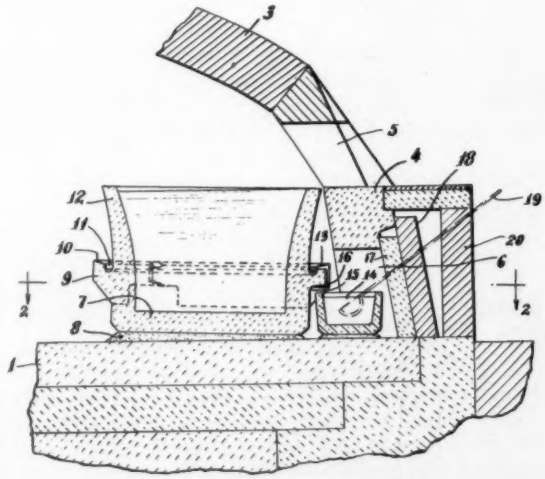


Fig. 5. Glass Melting Pot.

Radiation Filtering Glass. Patent No. 2,539,316. Filed July 10, 1947. Issued Jan. 23, 1951. No drawings. Inventor, Roger F. D. Navarre, alias Malherbe, Faisanderie, France.

The glass provided by this patent filters out the ultraviolet rays from any source of light and it is adapted for use in many places where such rays are objectionable.

The patent contains two claims, the first, as follows, directed to the glass and the second directed to articles made from this glass. A glass resulting from the fusion of sand, soda, potash, baryta, potassium nitrate, dolomite and black nickel oxide, the proportions being substantially as follows in weight for 100 parts:

	Parts
Sand	50
Soda	5
Potash	15
Baryta	10
Potassium nitrate	2.5
Black nickel oxide	12.5
Dolomite	5

The only reference cited was Gage et al., No. 1,305,793 dated June 3, 1919.

Sheet and Plate Glass

Sheet Drawing Machine. Fig. 6. Patent No. 2,539,398. Filed Jan. 19, 1946. Issued Jan. 30, 1951. Two sheets of drawings. Urban E. Bowes, Perrysburg, Ohio, inventor.

According to this method, the molten glass from the pool 11 is drawn upward through a float 12 by rolls 15. Just above the float is a pair of flattening members 16 which vibrate toward and from each other at about 1800 reciprocations per minute. These members are water cooled and act to flatten the glass between them while the sheet continues to move. This gives a much better surface than can be obtained by the use of rollers. When the sheet reaches the rolls 15, it has set too much to take further surface treatment.

The patent contains six claims and 15 references were cited by the Patent Office.

Miscellaneous Processes

Sheet Glass Cutting Device. Patent No. 2,538,901. Filed July 2, 1949. Issued Jan. 23, 1951. Four sheets of drawings, none reproduced. Assigned to Red Devil Tools, Irvington, N. J., by John H. Fancher.

This invention comprises a table, means for holding the sheet in position, and scoring means. A pressure bar applies pressure progressively along the scored line. By this device a small strip may be cleanly cut off without unintentional breaks.

The patent contains 11 claims and the references cited by the Patent Office were 787,122, Semmer, Apr. 11, 1905; 2,013,216, McCarthy, Sept. 3, 1935; and 2,174,183, Shaw, Sept. 26, 1939.

Method of Making Partly Colored Articles. Patent No. 2,538,935. Filed Oct. 8, 1945. Issued Jan. 23, 1951. One sheet of drawings not reproduced. Carl E. Erickson and Stephen E. Erickson, inventors.

The patent contains one claim which is as follows: The method of producing partly colored ware which comprises gathering glass upon a blow pipe, marvering the gather, introducing air into the gather to form a hollow glass blank and adding a small gob of colored glass to the top of the blank and pulling the said colored glass into the desired position on the blank, fusing the colored glass to the blank by reheating and then permitting the fused blank to cool, dipping the blank into the glass furnace to form an outer layer of glass on the blank and then blowing to final shape.

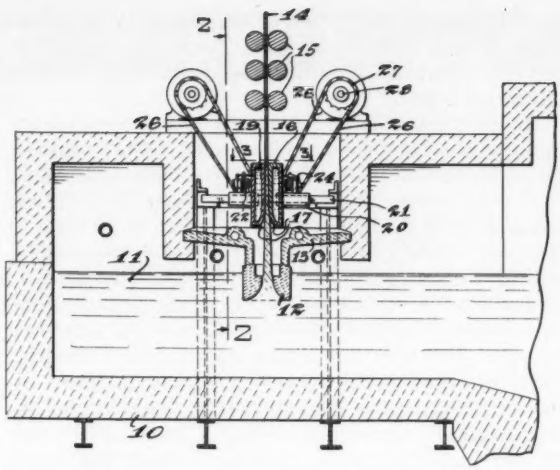


Fig. 6. Sheet Drawing Machine.

Six references were cited by the Patent Office. These were 344,415, Shirley, June 29, 1886; 389,595, Reder, Sept. 18, 1888; 952,908, Kaye, Mar. 22, 1910; 1,816,045, Haley, July 28, 1931; 2,094, Great Britain, 1891; and 3,355, Great Britain, 1902.

Glass Cutter. Patent No. 2,539,601. Filed June 7, 1949. Issued Jan. 30, 1951. One sheet of drawings, none reproduced. Oscar F. Walker, Grapeville, Pa., inventor.

This device comprises a head angularly adjustable on a handle. A diamond cutter and a lubricating wick are mounted in the head. It is particularly adapted for cutting large sheets.

The patent contains two claims and the only reference cited was Phillippe, No. 2,470,444, dated May 17, 1949.

Lamp Flare Holder. Patent No. 2,535,630. Filed Nov. 25, 1944. Issued Dec. 26, 1950. One sheet of drawings not reproduced. Assigned to Sylvania Electric Products, Inc., by S. J. Gartner and E. W. Barrett.

This device is for holding a flare and exhaust tube in position while they are being sealed together. While the parts are held in definite position, they are heated to form the seal.

The patent contains 4 claims and 8 references were cited as follows: 17,960, Dillaway, Aug. 11, 1857; 71,447, Birgham, Nov. 26, 1867; 576,824, Reynolds, Feb. 9, 1897; 1,409,339, Fischer, Mar. 14, 1922; 1,898,784, Mey, Feb. 21, 1933; 2,107,254, Horn, Feb. 1, 1938; 2,322,725, Bovio, June 22, 1943; and 2,322,728, Gates, June 22, 1943.

Treatment of Glass Sand. Patent No. 2,536,058. Filed July 13, 1949. Issued Jan. 2, 1950. One sheet of drawings not reproduced. Assigned to Minerals Separation North American Corporation by Wesley M. Houston of Lakeland, Fla.

The object of the invention is to remove iron impurities from the sand. The patent gives four examples of methods for practicing the invention, the first of which is abstracted below.

A 1000 gram batch of washed and screened glass sands was made into a thick aqueous pulp containing about 76% solids in a laboratory paddle type conditioner, to which while stationary was added sodium metasilicate in the amount of 0.5 lb. per ton of solids in the feed. Then agitation of the pulp was commenced, and to it were added: fuel oil 1.5 lbs., tall oil 1.5 lbs., and pine oil 0.2 lb., all per ton of solids in the screened feed. Agitation of the pulp was continued for about two minutes. The pulp was then transferred to a Minerals Separation Laboratory Airflow Flotation machine, diluted with water, and subjected to a primary froth-flotation treatment, thereby producing a froth-product rich in iron impurities and a residue (machine discharge) which is the high grade purified glass sand. The said froth-product was then agitated in a thin aqueous pulp containing about 20% to 30% solids for about 30 seconds, after the addition to it of sulfuric acid in the amount of 0.2 lb. per ton of solids in the screened feed. This pulp was then subjected to a secondary froth-flotation treatment which produced a froth-product rich in iron minerals which was discarded; and a residue which was the second machine discharge adapted to be mixed with untreated glass sands which are sold as a lower grade glass sand at a price less than the premium price commanded by the higher grade purified glass sand resulting from the first froth-flotation operation. The metallurgical results were as follows:

Product	Per Cent Wt.	Per Cent Total Fe	Per Cent Total Fe Distribution
Feed	100.0	.0117	100.0
Primary machine discharge, finished product	83.6	.0068	48.7
Secondary machine discharge	9.7	.0147	12.0
Froth-product to waste.	6.7	.069	39.3

The patent contains nine claims and the references cited were: 2,283,295, Tartaran et al., May 19, 1942; 2,433,633, Stokes, Dec. 30, 1947; and 2,461,875, Booth et al., Feb. 15, 1949.

Cellular Glass Slabs. Patent No. 2,536,192. Filed June 19, 1945. Issued Jan. 2, 1951. Three sheets of drawings, none reproduced. Assigned to Corning Glass Works by Jesse T. Littleton.

This patent discloses the method of making glass slabs which consists of heating a mixture of finely pulverized glass and a pulverized gassing agent in a mold big enough to form a block which can be cut into two finished slabs. This is heated to a sintering temperature to bloat the mass into a cellulated cake which is then superficially chilled to form a hard outer shell. This block is then split, while the interior is still soft, into two slabs which are then annealed and trimmed to finished size.

Detailed instructions for practicing this method will be found in the patent. The patent contains nine claims and the references cited were 2,118,707, Ingouf, May 24, 1938; 2,257,681, Haux, Sept. 30, 1941, 2,261,022, Fox et al., Oct. 28, 1941; 2,306,230, Dewey, Dec. 22, 1942; and 2,401,582, Owen, June 4, 1946.

Burning-off Machine. Patent No. 2,537,660. Filed Nov. 1, 1947. Issued Jan. 9, 1951. Nine sheets of drawings, none reproduced. John W. Eldred, Columbus, Ohio, inventor.

This machine is for burning-off the moil from things like tumblers and for making a good finish on the edge of the ware. The machine is of the turret type having 30 heads or chucks. The ware is placed in the chucks by a loading device and then advanced through a heating zone, a stretching zone where the moil sags away from the ware, an edge finishing zone, a cooling zone, and finally to the unloading station.

The machine is fully automatic and is provided with means for rotating the ware when necessary. This results in a high speed machine producing ware of superior quality.

The patent contains five claims and the references cited were: 1,577,543, Schrader, Mar. 23, 1926; 1,757,211, Parker, May 6, 1930; 1,996,814, Kadow, Apr. 9, 1935; 2,349,822, Gardner, May 30, 1944; 2,402,452, Schreiber, June 18, 1946; and 2,416,121, Screiber et al., Feb. 18, 1947.

GLASS COMPANIES CERTIFIED "EXCELLENTLY MANAGED" BY AMERICAN INSTITUTE OF MANAGEMENT

Eight companies in the glass industry are among 238 firms throughout the United States and Canada which are being awarded "Certificates of Management Excellence" for the year 1950 by the American Institute of Management, according to Jackson Martindell, President of the non-profit foundation.

The awards, which will be bestowed annually hereafter by the Institute, are based on its continuing study of more than 2,000 leading concerns and are designed to provide a base for research into corporate policies and procedures.

The eight honored glass companies include: Anchor Hocking Glass Corporation, Armstrong Cork Company, Corning Glass Works, Crown Cork & Seal Company, Inc., Hazel-Atlas Glass Company, Libbey-Owens-Ford Glass Company, Owens-Illinois Glass Company, and Pittsburgh Plate Glass Company.

In weighing the merits of each management, Mr. Martindell explained, credits are given for excellence in ten separate fields—economic function, corporate structure, health of earnings growth, fairness to stockholders, research and development, directorate analysis, fiscal policies, production efficiency, sales vigor, and executive evaluation.

AMERICAN POTASH ANNOUNCES QUARTERLY DIVIDENDS

The Board of Directors of American Potash & Chemical Corporation has declared a quarterly dividend of 50 cents per share on the Class A stock and the Class B stock of the corporation, payable March 15, 1951 to the holders of record on March 1, 1951.

The Board also declared a quarterly dividend of $1 per share on the Preferred Stock, payable March 15, 1951 to the holders of record on March 1, 1951.

Research Digest

Some Views on the Breaking of Glass Derived from the Examination of Fracture Surfaces

As a result of work by various investigators, the markings on fractured surfaces of glass have been classified under two main headings; namely, rib marks like waves with the convexity indicating the direction of motion, and hackle marks which run at right angles to the ribs and appear in the main body of the glass.

On the basis of work done on slowly moving fractures, it has been suggested that rib marks are rest points and possibly indicate a slight change of fracture direction. H. Marshall Bateson (*Journal of the Society of Glass Technology,* June 1950), based on evidence obtained from fractures formed under certain conditions, gives a different interpretation to the meaning of rib marks.

A glass rod which had been scratched with a file and broken by bending between the fingers with the scratch in tension showed the presence of intersecting rib marks on the fractured surface, the pattern being similar to the effect obtained when two stones are dropped simultaneously into a pond. Usually when the edge of a piece of glass is subject to impact, a shell-like fracture is formed and each individual shell containing rib and hackle marks is clearly separated from its neighbor. Even under high magnification and other lighting conditions, it is not possible to detect any intersection of the ribs either within the shell or at the boundary.

When this "intersecting rib-mark" type of fracture was first brought to his attention, the author had difficulty in making the idea of two simultaneous fractures fit in with the rest-point theory. Much time was spent in an effort to produce a "double fracture". On the basis of observations that cathode-ray-tube envelopes subjected to severe temperature shock at a thick section occasionally show the intersecting rib mark, an "intersecting rib-mark" type of fracture was obtained by suddenly applying a flame to a piece of ¼-inch plate glass marked with a line of cone flaws produced by dropping a ball bearing on it. Durofix replicas of this fracture surface showed that it could not be due to one fracture surface lying beneath another and yielding the intersecting rib-mark effect, for in that case the replica would not have the same appearance as the actual glass surface.

There appears to be some unknown factor affecting the formation of this intersecting ripple pattern (possibly related to shape and dimensions) for, although the above method of producing fracture was applied to many similar specimens, the ripples have not been discovered again. It has been noticed that the cathode-ray tubes have a curved section where the fracture occurs, and the markings have been in the curved top portion of a deliberately fractured tempered glass insulator. In support of this suggested dependence on dimensions, it was also stated that in eight times out of ten, the mirror area of a piece of ¼-inch glass rod, broken as described earlier, shows the effect. It is interesting to note also that a ¼-inch square section of glass yields similar results, but one of ½ x ¼ inch does not.

It seems reasonable to consider that these marks might be ripples on the glass surface, an idea first expressed by E. L. Hettinger. According to S. Timoshenko, waves propagated over the surface of an elastic body are similar to those resulting from a stone falling into water. At a great distance from the source, deformation is two-dimensional. The velocity of surface waves is less than that of distortion waves propagated through the body. A ripple was defined by Kelvin as a wave of length less than that of the wave propagated with the minimum velocity. Little is known about the actual viscosity and surface tension of glass at room temperatures, and it is assumed that for bulk glass the values are too high for there to be deformation without comminution. E. W. Taylor has recently shown how the surface of glass may be deformed in a plastic fashion and this is now put forward as a point in favor of the ripple suggestion. Poncelet and Murgatroyd are agreed on the supposition that as the atomic bonds are ruptured and two atoms fly apart, the sudden acceleration causes longitudinal waves to travel along a row of atoms in line with the fractured bond, i. e., perpendicular to the crack surface. The crack-tip stress is set up by a transverse wave in the plane of the crack, but there is as yet no evidence that rib marks are connected with the direct effects of bond rupture.

As the practical result of this theory of the formation of rib marks, it is suggested that workers on the strength of glass should seriously consider the effect of shock waves or transient-stress pulses on their results, especially in view of the knowledge which is becoming available on the subject of shock arising out of studies on flight at supersonic speeds. In his recent book, Haward quotes Timoshenko on elasticity, but leaves the impression that these dynamic forces can have little effect on static strength and fracture velocity. This may be correct for test purposes, but in the rough and tumble of use and abuse, shock waves must play their part. As an example, it can be stated that when cutting sheet or plate glass, if the diamond mark is tapped, a rippled fracture surface is obtained; but if, after starting a crack, the glass is pulled apart, an apparently perfectly smooth, polished surface results. It would also appear that the weakness of an edge (liability to chip on slight impact) is a matter of geometry and reflection of shock waves. It is suggested that the shape of the base of the modern lightweight bottle, ostensibly designed to strengthen the Murkatroyd belt by giving it elasticity (a purely static consideration), actually provides strength and a longer life because blows on the base edges are deflected to produce bruises or chips instead of fractures straight up and down the bottle.

It is generally accepted that hackle marks are formed in an area or zone where relatively high stress existed. Hackle runs in a direction parallel with that of the fracture and at right angles to any rib marks which may be present. In addition, a hackle is an individual fracture starting within the body of the glass. Bateson presents photographs of fracture surfaces which confirm that hackle marks are indeed separate fractures containing their own direction indicators, i.e., still smaller hackles running at right angles to the main hackle.

(*Continued on page* 147)

GLASS SYMPOSIUM AT AMERICAN CHEMICAL SOCIETY MEETING

A Symposium on the Physical Chemistry of Glass has been organized by Norbert J. Kreidl for the Spring Meeting of the American Chemical Society in Cleveland, April 10, from 9:00 A.M. to 5:00 P.M.

The chief purpose of the Symposium is to correlate new concepts and methods that have been applied within the spheres of either glass scientists or physicists and physical chemists and may be applicable in the other sphere. The main topics are constitution, surface, anelasticity, magnetism, and luminescence.

The session is planned to emphasize discussion over presentation and the number of speakers, which includes well noted foreign scientists, is limited.

The proposed schedule of the Symposium includes *Morning:* Introduction, N. J. Kreidl, Chemical Research Director, Bausch and Lomb Optical Co.; The Effect of High Energy Radiation on the Absorption and Luminescence of Glasses and Crystals, James H. Schulman, Robert J. Ginther, Clifford C. Klick and Esther W. Claffy, Crystal Branch, Metallurgy Division, Naval Research Laboratory; Anelasticity of Glass, J. V. Fitzgerald, G. S. Bachman and K. M. Laing, Research Laboratories, Pittsburgh Plate Glass Co.; Discussion; Magnetism and the Structure of Glass, P. W. Selwood, Northwestern University; Magneto-Optic Properties and Constitution of Glass, H. Cole, Research Laboratories, Pilkington Brothers, Ltd., St. Helens, Lancashire, England; Discussion.

Afternoon: Physical Chemistry of Glass Polishing, A. Smekal, Head of Physics Department, University of Graz, Austria; Discussion; Acid-Base Relationships in High Temperature Systems, L. F. Audrieth, University of Illinois; The Equilibrium Density of Glass and Its Relation to the Atomic Arrangement, R. W. Douglas, Research Laboratories, General Electric Co., Ltd., Wembley, England; Discussion; Structure and Properties of Crystalline and Vitreous Boron Oxide; Stephen W. Barber, Owens-Illinois Glass Company, Toledo, Ohio, and Kasimir Fajans, University of Michigan; Discussion.

GLASS CONTAINER ADVISORY COMMITTEE AND NPA HOLD MEETING

Members of the Glass Container Manufacturers Industry Advisory Committee met recently with the National Production Authority to discuss the potential of the glass container industry in the present national emergency.

Committee members said that a lack of basic materials, such as cullet, soda ash, and cobalt, is retarding an increase in the production of jars, bottles, and other glass containers now in demand because of steel, tin, and other metal shortages. They said that the shortage of paper for cartons is also beginning to be felt.

NPA appointed a task group to study glass container simplification techniques, which the industry said would boost production rates. Officials said a paper conservation and salvage system is being considered and that steps are being taken to save paper wherever possible. Concern is felt in connection with future fuel oil supplies for glass container plants and difficulty is being experienced in getting glass decolorizers.

Participating in the meeting were Charles A. Lewis, Acting Chief of the Containers and Packaging Division of NPA, and H. B. Esselen, Head of the Glass Containers and Closures Section. The Advisory Committee working with the NPA consists of the following members: S. B. DeMerell, Anchor Hocking Glass Corporation; J. C. Feagley, Armstrong Cork Company; E. F. Ball, Ball Brothers Company; G. A. Mengle, Brockway Glass Company, Inc.; C. R. Avery, Chattanooga Glass Company; J. M. Foster, Foster-Forbes Glass Company; L. F. Gayner, Gayner Glass Works; F. W. McDonald, Glass Containers, Inc.; J. S. Algeo, Hazel-Atlas Glass Company; J. A. Bernier, Alexander H. Kerr & Co.; R. R. Underwood, Knox Glass Associates, Inc.; J. S. Heuisler, Maryland Glass Corporation; H. S. Wade, Owens-Illinois Glass Company; and F. B. Pollock, Thatcher Glass Manufacturing Co., Inc.

Acting as closure consultants to the Glass Containers and Closures Section are H. B. Carr, Owens-Illinois Glass Company, and Stanley Dennis, Crown Cork & Seal Company.

G.C.M.I. OPENS WASHINGTON OFFICE

Announcement has been made that the Glass Container Manufacturers Institute has opened a Washington office in the Commonwealth Building. The new office will be in charge of Harry W. Kuni, Secretary-Treasurer of the Institute.

WALSH PLANT EXPANSION

Following the recent issuance of a certificate of necessity granted by the National Security Resources Board, Walsh Refractories Corporation is now engaged in major expansion of its fire brick manufacturing facilities at its Vandalia, Missouri, plant. Considerable progress has already been made toward the objective of increasing annual production by an additional one thousand carloads or approximately ten million 9-inch equivalents of fire brick and other refractory products.

With the completion of the project, which includes a large, new tunnel kiln, the company will make available to the glass, steel, and other basic industries additional quantities of dry press tunnel kiln burned ladle brick, super duty and high burn super duty fire brick. It is expected that the new plant will be in full operation by early summer, 1951.

WESTINGHOUSE ADDS TO NEW TUBE DIVISION STAFF

The appointment of Harry D. Hanafus as purchasing agent of the recently formed Westinghouse Electronic Tube Division has been announced by Andrew H. Phelps, Vice President.

Mr. Hanafus, who will make his headquarters at the company's plant in Bloomfield, New Jersey, joined the Westinghouse Lamp Division purchasing department in Bloomfield in 1944, becoming assistant purchasing agent of the Division the next year. His experience in the purchase of electronic tube and lamp manufacturing equipment and materials dates back 21 years. Prior to joining Westinghouse, Mr. Hanafus was purchasing agent for the Radio Corporation of America tube manufacturing divisions.

Also announced was the appointment of Harry F. Blythe as manager of accounting for the Tube Division. Mr. Blythe is now staff assistant to the Westinghouse Lamp Division's manager of accounting.

Current Statistical Position of Glass

Employment and payrolls: Employment in the glass industry during December 1950 fell off to reach a preliminary 127,400 persons. This is about 1 per cent below the adjusted November figure of 128,700. During the month of December 1949, employment had been reported at 107,100, close to 19 per cent below December 1950.

Payrolls for December 1950 were reported at a preliminary $36,221,094. This represents a drop of about 3 per cent from the adjusted $37,404,939 paid out by glass manufacturers during November 1950. Payrolls during December 1949 were $27,028,751, which is 34 per cent below December 1950.

Glass container production for January 1951, based on figures released by the Bureau of Census, soared into the ten million gross bracket with a total of 10,278,883 gross of containers produced. Compared with the previous month's 9,357,059 gross, this represents a jump of close to 10 per cent. During January 1950, production had been 7,934,499, which is 29 per cent below January this year.

Shipments of glass containers also continued upward and during January 1951 the number shipped was 9,719,684 gross. This is about 3 per cent above the 9,413,143 gross shipped during December 1950. Shipments during January 1950 were 7,590,133 gross, which represents a difference of 28 per cent when compared with January 1951 shipments.

Stocks on hand at the close of January 1951 were 7,286,483 gross. This is about 7 per cent higher than the 6,812,160 gross on hand at the close of December 1950. Stocks on hand at the close of January 1950 were 9,365,383 gross.

GLASS CONTAINER SHIPMENTS

(All figures in Gross)

	January 1951
Narrow Neck Containers	
Foods	814,112
Medicinal & Health Supplies	1,404,685
Chemicals, Household & Industrial	696,736
Beverages, Returnable	446,662
Beverages, Non-returnable	10,173
Beer, Returnable	204,125
Beer, Non-returnable	245,475
Liquors	1,251,442
Wines	279,923
Toiletries & Cosmetics	579,521
Sub-total (Narrow)	5,932,854
Wide Mouth Containers	
Foods	2,278,272
Dairy Products	324,373
Home Canning	*
Medicinal & Health Supplies	435,825
Chemicals, Household & Industrial	147,136
Toiletries & Cosmetics	213,818
Packers' Tumblers	119,872
Sub-total (Wide)	3,519,296
Total Domestic	9,452,150
Export Shipments	267,534
Total Shipments	9,719,684

* This figure included with Wide Mouth, Foods.

GLASS CONTAINER PRODUCTION AND INVENTORY

(All figures in Gross)

		Production January 1951	Stocks January 1951
Foods; Medicinal & Health Supplies; Chemicals, Household & Industrial; Toiletries and Cosmetics	Narrow Neck	3,891,887	2,785,748
	Wide Mouth	3,290,193	2,457,494
Dairy Products		395,891	290,877
Home Canning		*	*
Beverages, Returnable		531,182	485,043
Beverages, Non-returnable		14,046	24,130
Beer, Returnable		257,094	174,636
Beer, Non-returnable		266,980	211,627
Liquors		1,178,667	441,066
Wines		317,793	300,145
Packers' Tumblers		135,150	115,717
Total		10,278,883	7,286,483

* This figure included with Wide Mouth, Foods.

Automatic tumbler production for January 1951 jumped 22 per cent to reach 6,959,061 dozens. This is an increase over the 5,701,631 dozens produced during the previous month. During January 1950, production had been 6,125,243 dozens. Shipments of automatic tumblers also jumped and were reported to be 6,831,437 during January 1951. This is 30 per cent more than the 5,252,988 dozens shipped during December 1950. Shipments during January 1950 were 4,980,813 dozens. Stocks on hand at the close of January 1951 were 9,601,931 dozens, or close to 3 per cent less than the 9,886,711 dozens on hand at the close of December 1950. Stocks on hand at the end of January 1950 were 9,824,671 dozens.

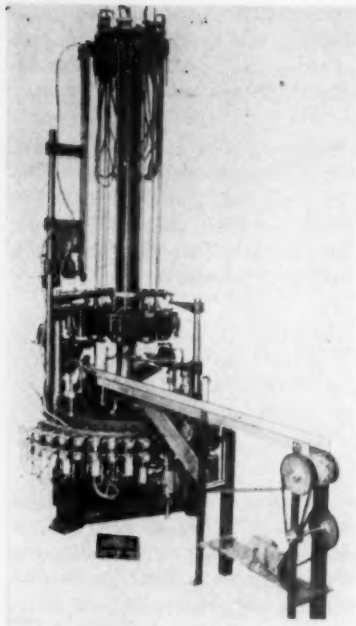
Table, kitchen, and household glassware: Manufacturers' sales of machine-made table, kitchen, and household glassware rose 14 per cent for the month of January 1951 to reach 3,666,519 dozens. This is an increase over the previous month's sales of 3,218,325 dozens. During January 1950, sales had been 2,643,586 dozens. At the close of the 12-month period ending January 1951, total manufacturers' sales have reached 40,455,302 dozens. This is close to 4 per cent above the 38,942,868 dozens sold during the corresponding period ending January 1950.

CARBORUNDUM NAMES REFRACTORIES ENGINEER

William R. Rogers has been transferred to the Philadelphia Sales District Office of The Carborundum Company at Bristol, Pa., from the Refractories Division of the Company at Perth Amboy, N. J., to act as Refractories Engineer, assisting D. W. Polhemus, Refractories Engineer for that district.

Mr. Rogers has been employed by the Refractories Division of The Carborundum Company since shortly after graduation, with his B.S. degree in Mechanical Engineering, from Cornell University in 1948.

New Equipment and Supplies



NEW AUTOMATIC BULB-BLOWING MACHINE

Kahle Engineering Company, North Bergen, New Jersey, has announced the distribution of a new automatic bulb-blowing machine designed to fill the need for a more compact, more efficient space-saver. The new Kahle machine has been reduced to only 130" high, with side supports eliminated in its construction.

New features of the bulb-blowing machine include the incorporation of motor operated cutting knives to replace old-style flame cutting in the interests of more positive and faster production. New improved chucks reduce the waste of tubing ends. In order to increase the ease of adjustment during the operation of the machine, a new type airblo system has been installed on the lower part of the unit.

If desired, the new Kahle machine can be equipped with automatic tube feed elevator which returns the feeding chuck automatically to loading position. Aside from hand feeding of four foot lengths of glass tubing, all other operations are automatic.

Allowing for speeds up to 2400 per hour, bulbs can be blown into a mold of any feasible design or shape on the Kahle machine. Bulbs can be blown up to 2½" o.d. by 5½" over-all length, including stem and tubulation.

FIRED HEATERS FOR PROCESS HEATING

Struthers Wells Corporation, Warren, Pa., has announced a standard line of direct fired heaters, capacities 100,000 BTU per hour to 15,000,000 BTU per hour. This equipment is designed for a wide range of applications, including direct circulating heating using heat transfer mediums such as Dowtherm, and for direct heating of vapors and liquids. Temperatures range to 750°F. or above.

The equipment is designed for high thermal efficiencies and trouble free operations. Complete automatic control systems are available which largely eliminate operating attention.

MIDGET BLAST CLEANING UNIT

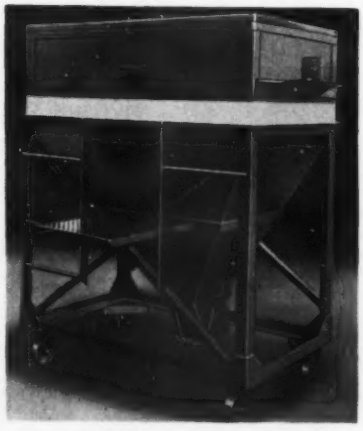
Pangborn Corporation, Hagerstown, Maryland, (write Attention B. H. Marks) has announced a new midget unit for liquid blast cleaning.

In the production of glass, plastic, rubber, and die cast and forged products, principal uses of the new machine will be in the elimination of much hand polishing of dies and molds permitting new dies and molds to be hand finished wholly in the soft state before heat treatment with liquid blast cleaning doing all the final polishing and removal of stain and scale after heat treatment.

Called the Number O Type of EZ Hydro-Finish Blast Cabinet, the new unit uses the same wide range of abrasives (as fine as 5000 mesh) as the larger units, and can hold tolerances on blasted parts to within 0.0001 of an inch. It requires only 17" x 22½" of floor space; stands on easily adjusted legs; requires only 110 volt AC to drive its filter and dust bag motor; consumes from 5 to 20 cfm of air at 80 psi; and is provided with a chamber light, right and left hand holes, a quick-opening valve for knee or leg operation, and an ample observation window protects from splash and dirt by a cross-current of fresh inlet air.

PORTABLE STORAGE HOPPER

The Klaas Machine & Mfg. Company, 4320 East 49th Street, Cleveland 25, Ohio has announced the manufacture of a portable storage hopper.



Two features of this equipment are (1) the unit serves as a temporary storage medium, and (2) the storage unit becomes a conveyor of material as the material is needed. As a container, the hopper is suitable for dry pre-mixed batches such as are required in glass, chemical, enameling, and rubber plants.

The hopper has a bottom dump to facilitate charging the material from above into a furnace, for example, below. The storage-conveyor-dump unit is made of welded sheet metal and structural steel frame. The wheels not being fixed, movement of the unit can be in any direction. The size is 30′ wide by 48" long, 6′ high, and the capacity is 1 cubic yard.

CATALOGUES RECEIVED

Foote Mineral Company, 18 West Chelten Avenue, Philadelphia 44, Pa., has announced that its current issue of "Foote Prints" is devoted to the subject of lithium in ceramics.

The publication opens with an editorial, followed by a discussion of Foote ceramic research and development and the future of lithium. Under a chapter heading "Lithium in Glass, Glazes, and Enamels" data is included concerning Atomic Weight of Lithium, Ionic Bond, Ionic Radius, Bond Strength, Coordination Number, Lithium Ion as a Network Modifier, Devitrification, Effect on Softening Point, Effect on Thermal Expansion, Effect on Surface Tension, Effect on Chemical Resistivity.

Other subjects discussed include "Lithium in Clay Dispersions", "Lithium in Industrial Lubricants", "Industrial Lithium Salts", and "Industrial Lithium Minerals". A bibliography of lithium ceramic references follows.

Richardson Scale Company, Clifton, New Jersey, has issued a new Proportioning, Blending, and Process control equipment bulletin.

The two-color bulletin, which contains 21 pictures of typical Richardson control panels and automatic scales, is devoted to descriptions and specifications of the various Richardson precision units. The scales described are of the "pre-weighing" type, which refers to the delivery of prescribed amounts of material, as opposed to the more familiar "post weighing" which means the determination of the weight of an unknown mass.

R. S. Aries & Associates, 400 Madison Avenue, New York 17, New York, has issued a new pamphlet outlining the firm's services.

As specialists in the chemical process industries, the company's pamphlet lists the seven steps in setting up a new process.

THE RIGHT *Color* ENHANCES BEAUTY

● Colors that flatter some women are unbecoming to others. It's just a case of finding the right color for the right individual. You may have the same problem in finding the right color to fit your ware. But here's an easy solution: Call on Drakenfeld to help you formulate colors exactly suited to the needs of your particular processing techniques and high standards.

Our broad knowledge and research facilities may hold the answer that can produce greater profits for you. For over three-quarters of a century we have been saving time, money and effort for ceramic manufacturers, large and small. Whatever your needs, whether you want colors matched, created or brought up to date, we believe our know-how can be of real value to you.

Let us demonstrate how our friendly counsel has helped others—how it can serve you. For more production and lower costs, for fewer rejects and better ware, investigate the advantages of Drakenfeld service. Write or phone for a meeting date today.

CALL ON **Drakenfeld** *YOUR PARTNER IN SOLVING COLOR PROBLEMS*

B. F. Drakenfeld & Co., Inc., 45-47 Park Place, New York 7, N. Y.

Factory and Laboratories: Washington, Pa.
Pacific Coast Agents: Braun Corp., Los Angeles 21,
Braun-Knecht-Heimann Co., San Francisco 19

DEPENDABLE SERVICE ON:

Acid, Alkali and Sulphide Resistant Glass Colors and Enamels . . . Crystal Ices . . . Squeegee and Printing Oils . . . Spraying and Banding Mediums . . . Glassmakers' Chemicals . . . Glass Decolorizers . . . Decorating Supplies.

TRADE AGREEMENTS ACT EXTENDED WITH AMENDMENTS

Four curbing amendments to the Trade Agreements Extension Act were recently passed when House Republicans found liberal support from the Democratic majority in what is considered a keynote of our foreign policy.

The first limitation, sponsored by Richard M. Simpson, Republican of Pennsylvania, to restore the Peril Point Amendment, started the move for approval by the majority, when it was approved by 198 to 107 on a standing vote.

Following this, John W. Byrnes, Republican of Wisconsin, introduced an amendment to bar future trade agreement concessions to Communist dominated countries. This was approved by a voice vote.

Cleveland M. Bailey, Democrat of West Virginia, then offered an amendment requiring an Escape Clause to be included in all future trade agreements. It stipulates that the Tariff Commission should study the effects of trade agreements. It would investigate claims of injury to American industry arising from imports. This was approved 198 to 107 on a standing vote. The amendment states "that the Tariff Commission shall deem a downward trend of production, employment, and wages in the domestic industry concerned, or a decline in sales and a higher growing inventory attributable in part to import competition, to be evidence of serious injury or threat thereof".

An amendment forbidding tariff cuts on foreign farm goods competing with American products unless the imports sell at a higher price than the U. S. support price was then approved 174 to 110 on a standing vote.

When all of these amendments had been passed, the House then by a voice vote approved a bill to extend the Trade Agreements Act for three years. The bill now goes to the Finance Committee of the Senate.

G.C.M.I. SUSPENDS PROMOTIONAL ACTIVITY

Victor L. Hall, General Manager of the Glass Container Manufacturers Institute, has announced that due to the national emergency promotion activities of the Institute in behalf of certain glass products have been suspended.

Mr. Hall stated that in view of the changes which world conditions are imposing on the American economy, the Board of Trustees has decided that the desirability of an industry-wide commodity marketing program had to be reappraised.

During the past two years, the Institute has sponsored advertising and merchandising campaigns to extend markets for certain types of packages, such as the milk bottle, glass jars for baby food, and single trip bottles for malt beverages.

Mr. Hall added that while group promotional activities have been suspended, the Institute's Marketing Committee will be continued.

CORRECTION: In the February 1951 issue of THE GLASS INDUSTRY, page 72, the illustrations designated as Figures 2 and 3 should be transposed.

Also, on page 92, the first ratio shown in the table should read:

$$\frac{\text{Surface Area of Mold}}{\text{Surface Area of Glass}}$$

PEMCO RECEIVES MERIT AWARD

The Pemco Corporation has been presented with the 1951 Merit Award of the American Society of Industrial Engineers for "excellence in engineering and manufacturing". The award is made by the engineering society to one outstanding manufacturer in each basic industry and came, it was explained, in recognition and appreciation of Pemco's high standards in facilities, formulation, processes and products, and leadership in the ceramic industry.

The presentation was made at a ceremony over a local television broadcast. Herbert Turk, Executive Vice President of Pemco, accepted the award on behalf of the firm from R. L. Crinnian, National President of the Engineers Society.

Mr. Crinnian in presenting the citation declared, "The award is significant of the Society's appreciation of signal contributions made by the Pemco Corporation to the industrial arts and sciences. This company is the first industrial firm in the state of Maryland to receive such an award . . . and the 27th company to receive such an award in all categories of industry in the United States."

Mr. Turk declared that his company "is deeply honored by this merit award and proud that Pemco had been singled out to receive it for the ceramic industry."

DIAMOND ALKALI ELECTS VICE PRESIDENT

The appointment of A. L. Geisinger to a vice presidency of Diamond Alkali Company has been announced by President Raymond F. Evans following action by the Board of Directors.

In this new assignment with the company, which he has long served in executive capacities, Mr. Geisinger will have charge of Diamond's activity in the organic chemistry field. At present Mr. Geisinger also is President of the Martin Dennis Company, a Diamond division.

Mr. Geisinger joined Diamond Alkali Company in 1919. His first major assignment was the direction of the company's entry into the silicate business. He designed, supervised construction and later operation of Diamond's first silicate plant at Cincinnati, Ohio, launched in 1921. In the ensuing years, he filled the same roles in the establishment of five other silicate plants throughout the country. Along with heading all operations of the silicate division, for many years he also directed sales of silicate chemicals.

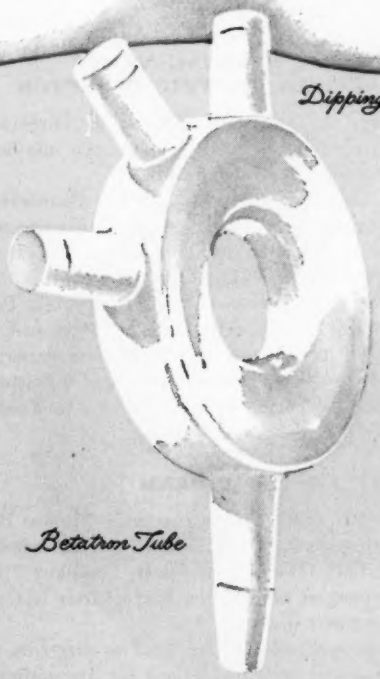
The Colonial Insulator Company, Akron, Ohio, has been successfully manufacturing quality porcelain products since 1894. Which means they're in a position to recognize a good thing in the ceramics field when they see it. They saw it in ALCOA Alumina.

After extensive experimental work, Colonial recently began producing porcelain bodies containing approximately 15% ALCOA Calcined Alumina. The results were even better than expected. ALCOA Alumina not only lowered the coefficient of expansion and reduced thermal deformation, but increased resistance to abrasion, thermal and mechanical shock. Colonial porcelains are now stronger, whiter, more impervious and dielectrically superior to the old product—because of ALCOA Alumina.

High-Voltage Insulator

BUILDING BETTER BODIES WITH ALCOA ALUMINA

Dipping Form–Rubber Glove



Betatron Tube

All over the country, *successful* ceramic manufacturers are doing great things with ALCOA Alumina. Whether they make abrasives or glazes, refractory bricks or glass, they know that by adding this uniformly pure aluminum oxide to their mixes, they make their products *better.*

For the qualities you want most in your ceramics, rely on ALCOA Alumina. It can make any ceramic product —*your product*—the best of its kind. We'll gladly tell you how. Write to: ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 613c Gulf Building, Pittsburgh 19, Pennsylvania.

Alcoa Chemicals

ALCOA ALUMINUM

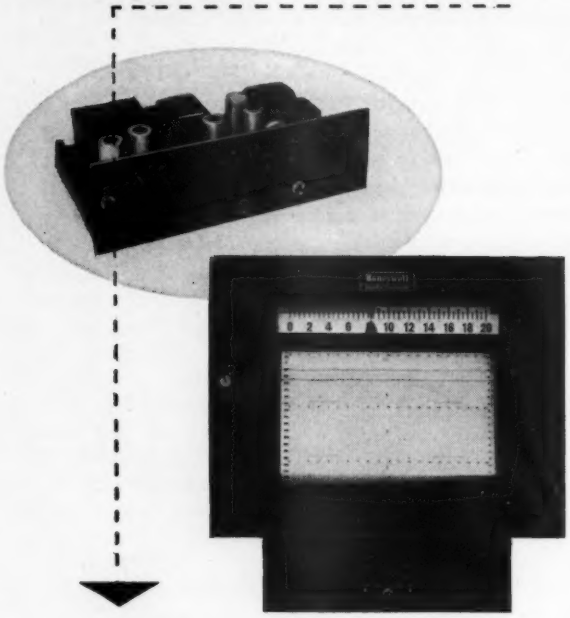
ALUMINAS and FLUORIDES

ACTIVATED ALUMINAS • CALCINED ALUMINAS • HYDRATED ALUMINAS • TABULAR ALUMINAS • LOW SODA ALUMINAS ALUMINUM FLUORIDE • SODIUM FLUORIDE • SODIUM ACID FLUORIDE • FLUOBORIC ACID • CRYOLITE • GALLIUM

BROWN INSTRUMENTATION IS THE Plus-Factor

For

PULSE FIRING
OF YOUR FURNACE



The Electr-O-Pulse

ELECTRIC PROPORTIONAL CONTROL RELAY

You can obtain more accurate furnace control with the *Electr-O-Pulse* proportional control relay. It proportions the *on-time* of a contactor, solenoid, or motor valve in accordance with furnace demand . . . delivers an average heat input by changing the ratio of "on" to "off" time. With automatic compensation for load changes, straight line control on an on-off basis is realized.

Check the list of outstanding features . . . then call in your local Honeywell engineer for a discussion of how they will benefit your plant. Branch offices in more than 80 principal cities of the United States, Canada, and throughout the world.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4521 Wayne Ave., Philadelphia 44, Pa.

CHECK THESE OUTSTANDING FEATURES!

- √ INDEPENDENCE OF CONTROL ADJUSTMENTS — *Widest range of adjustments; completely non-interacting.*
- √ FACTORY WIRED — *Integral mounting wired at factory, eliminates errors and simplifies installation.*
- √ UNIVERSALLY ADAPTABLE — *Can be used with instrument slidewire resistance values from 50 to 1000 ohms.*
- √ COMPACT DESIGN — *Two instruments with integral relays fit on a 24" x 42" panel.*
- √ SIMPLIFIED SERVICING — *Plug-in chassis makes unit accessible.*
- √ MANUAL CONTROL — *Relay includes manual control adjustment.*
- √ AUTOMATIC RESET — *Compensates for load changes automatically.*

Write for Specification Sheet 195

MINNEAPOLIS Honeywell
BROWN INSTRUMENTS

GLASS DIVISION MEETING SOUTHERN CALIFORNIA SECTION OF THE A. C. S.

Robert D. Gray, Professor of Economics and Industrial Relations at the California School of Technology, addressed the Southern California Glass Division of the American Ceramic Society February 14, 1951, at the Hacienda Country Club. The address, "Industrial Relations in 1951", involved the changing manpower situation throughout the country.

The speaker emphasized the seriousness of the situation, reviewed existing conditions, and delved into the future. Analysis of the reported surplus of manpower over the 1942 period reveals that the situation is less favorable than statistics indicate, and that industry must look to other sources for solution of the problem. Within six months there will be a much increased demand on manpower for the defense industries, part of which will come from non-defense industries.

Relief may be accomplished by extending the 40-hour week, by using more men over 65 years of age, and by utilizing to better advantage partially disabled persons. Non-defense plants will find it necessary to review their own organizational structure. Mr. Gray emphasized the need for favorable managerial attitudes, training programs, and suggestion systems as means for stimulating the interest of the worker in his own organization.

Attendance at the meeting included top executives from several allied industries in Southern California, many production men, and a few educators. Victor C. Swicker of Whittier was re-elected Chairman of the group. Glen Henning of the Maywood Glass Company was elected Co-chairman, and Ben Martin of the Overmyer Mould Company was elected Secretary and Treasurer. This group, which consists of representatives from practically all of the glass manufacturing companies in Southern California, meets every other month.

ANCHOR HOCKING NAMES E. E. ALLISON TRAFFIC DIRECTOR

The appointment of Ernest E. Allison as Director of Traffic, effective February 5, 1951, has been announced by Anchor Hocking Glass Corporation.

Mr. Allison has been associated with The Pennsylvania Railroad during the past 26 years, holding various responsible positions in Freight Traffic Departments and serving most recently as District Freight Agent.

In 1944, as Special Representative of the Freight Traffic Department at Pittsburgh, Mr. Allison developed and administered training courses for department personnel. He is author of the book "Fundamentals of Transportation", which has been used extensively by The Pennsylvania Railroad for employee instruction.

L-O-F DIVIDEND

A dividend of 50 cents a share payable March 10 to shareholders of record March 3 has been declared by directors of Libbey-Owens-Ford Glass Company. This is the same amount as paid in the first quarter last year on the basis of present shares.

John D. Biggers, President, reported to directors that January business had been the largest for any month in the history of the company and substantially above the same month last year.

- **Increased coverage**
- **Finer decorative detail**
- **Anti-slugging**

• Harshaw's white glass enamel, in impartial production runs, has decorated 8% to 35% more bottles per pound of glass enamel than other brands.

Also, sharper decorative lines and smaller letters are made possible with this new white glass enamel for decoration of glassware by the silk screen process.

Another important advantage is its anti-slugging properties. When production is resumed after a slow down or stoppage there is little or no smearing of your product. Harshaw's new white does not have the tendency to "seep thru" the silk screen.

Contact the nearest Harshaw branch office for additional information or quotation.

HARSHAW

white glass enamel

THE HARSHAW CHEMICAL CO.
1945 East 97th Street, Cleveland 6, Ohio
BRANCHES IN PRINCIPAL CITIES

CLEVELAND · CHICAGO · CINCINNATI · DETROIT · HOUSTON · LOS ANGELES · PHILADELPHIA · PITTSBURGH · NEW YORK

(*Continued from page* 126)

ing to temperatures above the softening point can be preserved, but in both cases what is most striking is that these phenomena are only to be observed on extremely minute volumes of glass, of the order of 1/100th of a millimeter in thickness. To get these frozen states, it is necessary to have recourse to extremely rapid chilling (around 1/5,000th part of a second in the case of industrial textile).

Since the hypotheses of Section II appear fruitful and structural concepts appear a fairly safe guide, we hesitate to abandon the idea of a structural hysteresis at high temperatures. We must ask ourselves if expansion tests are the most suitable to demonstrate the phenomena we are looking for. Linear expansion, or density, which latter is a direct measure of volume expansion, reveals the frame-work, the psuedo-lattice built out of the network ions, primarily the Si-O pattern. Thus far, we have described a structural state of molten glass, a structural heterogeneity, in the form of a psuedo-lattice more or less degenerate, but sketched in terms fundamentally of either a more or less pronounced fragmentation of aggregates or in terms of a loosening and disorganization of the entire molten mass.

The experiments described above indicate that this fragmentation or loosening does not persist throughout a fairly rapid course of cooling.

But in this network, there is nothing to prevent *fluctuations of the population of the modifying ions* (and we are thinking primarily of the most mobile alkali ions) *being "trapped" by the network as it reconstitutes itself.*

The silicon and oxygen ions are compelled by the nature of their covalent bonds to take up positions of little variability and are in consequence ready on very short notice to modify the strength of these bonds. The alkali ions, quietly ensconced in the interstices of a network of a vitreous state that has been stabilized at low temperature, can at high temperatures be displaced among the loosened interstices so that here and there we get ionic impoverishments and enrichments. These fluctuations affect only volumes of molecular dimensions and are equalized from one moment to another.

When glass is melted a sort of opalescence comes over the melt at temperatures of above 1,250°C. The diathermancy becomes less. The displacement of the ultraviolet absorption band to longer wavelengths is insufficient to explain this opacity. At 1,450°C. even colorless glass has an emissivity which is not very different from that of a black body. This opalescence reminds one of the critical opalescence of liquids when very minute fluctuations of density become evident. If now a sudden chilling of the glass takes place, the network is reconstituted or tightened up. The fluctuations are stopped. In short, the chilling produced by contact with a cold body (a mold, a roller, table, or marvering plate) proceeds from layer to layer. It will be mostly the first layers that are affected, folded, cold-worked or rolled, which are likely to show heterogeneity. In this would lie the explanation of chill-waves, constituting once more what we call physical heterogeneity, because chemical analysis is quite unable to reveal variation in composition in these waves or surface markings.

There would not be, however, any difference between physical and chemical heterogeneity except in respect of the scale on which it is detectable. Chill-waves do not disappear as a result of a reheating sufficient to release mechanical stresses. It is necessary to go up to the molten state in order to re-absorb them. Their disappearance is none the less more easily accomplished than that of chemical striae, since the regions in which these heterogeneities are present are on a molecular scale, whereas the chemical kind are macroscopic and demand a long period of diffusion.

Where a hot layer and a cold layer come in contact, there may even be an accumulation of ions due to the different mobilities of these latter and thereby an electric field may be set up. Kantzer and Leclerc have succeeded in measuring in the St. Gobain Glass Works laboratory potential differences between layers of glass at different temperatures, the cold electrode appearing positive with respect to the external circuit.

But this ionic heterogeneity cannot of itself be the cause of a changing instability since it directly concerns only the network.

A glass having physical "waves" is useless for optical purposes, but is not abnormal in its mechanical properties.

On the other hand, the concept of the *trapping* of ions suggests to us a more general interpretation.

In the high-temperature state the psuedo-lattice is loose, many of the Si-O bonds necessarily being broken. We have postulated that the relative positions of atoms constituting the network can vary but little, but this can only be true for a portion of them. In the course of a sudden cooling, only those atoms already bonded or already in a favorable position to establish anew a covalent bond, are going to contribute to the formation of the network. The others, frozen in an unfavorable position, are going to remain inactive, "trapped", or, as it were, "boxed up" among the elements of an enlarged network, but none the less possessing physical properties quite similar to those of a structure completely reconstituted. By way of analogy, we might say that a cage made up of iron bars will expand in precisely the same fashion whether some of the bars are missing or not.

We might, in fact, speak of a sort of primary skeleton in whose interior are trapped various elements ready to amalgamate with and to complete the skeleton in the course of a heat treatment of long duration, which we call "fine annealing", but ready also to recapture their liberty the moment a moderate rise of temperature opens some cracks in their trap. We might explain in this rather intuitive fashion the practice of quenching before bending (previously mentioned).

It would be these entrapped elements which would introduce the factor of instability. In the course of a slow organization of the network, beginning with the primary skeleton, new bonds should tend to make the scaffolding more compact, and so to create new forces independent of the existence or non-existence, in the first instance, of stresses due to cooling.

In this fashion there might be reconciled the structural hypothesis, apparently with virtually no hysteresis at high temperatures, so far as mechanical properties

are concerned, and the constitutional lag which accounts for the technical facts that we have described.

Translator's note: The term "covalent bond" as used by Mr. Peyches and here translated literally, appears to mean the same as "valence bonding", typical of the crystal structure of abrasives, as distinct from "ionic bonding", typical of simple salts in the solid form.

BAUSCH & LOMB APPOINTMENT

The appointment of Dr. Robert J. Meltzer to Bausch & Lomb Optical Company's Scientific Bureau has been announced by Carl L. Bausch, Vice President in charge of Research and Engineering.

A physicist, Dr. Meltzer graduated from Rensselaer Polytechnic Institute and earned his doctorate at Johns Hopkins University. Before enrolling at Johns Hopkins, he served for two years as a research assistant for the armed services' guided missiles program at the Naval Research Laboratories and at Massachusetts Institute of Technology. In this capacity, he specialized in designing and building spectrographic and other optical equipment.

ITO CHARTER HELD UP

A recent State Department release says "the proposed Charter (ITO) ..... should not be re-submitted to the Congress". This would indicate the end of the ITO Charter, commonly known as the Havana Charter, for without the U. S. ratification, it is assumed that the other countries will not activate it.

GLASS INDUSTRY IN ITALY IN 1950

At present some 360 factories with a total of about 36,000 workmen are engaged in the glass industry in Italy. These factories have a potential output of some 400,000 tons yearly of various types of glass.

The principal item in their production is sheet glass which accounts for 34% of the whole output. Next come: white glass, 30%; green glass, 22%; glass for technical and scientific use, electric bulbs, laboratories, etc., 10%; and artistic glass, 4%.

During 1950 all of the existing plants were working and the output can be considered about 25% higher than in 1949. The production of mechanical hollow glass (bottles, etc.) has been doing particularly well.

The situation was good as regards the supplies of fuel, electric power, and raw material but recently some difficulty in securing adequate quantities of sodium carbonate have been experienced.

As regards sands, Italian factories turn more and more to supplies from France and Holland.

The costs of raw materials and labor are particularly high in this branch of Italian industry and this prevents the development of exports. Furthermore, Italian factories are finding that custom duties on imported glass are not sufficiently high to protect them.

The sale of bottles on the home market has been promoted considerably by the recent spread of the use of soft drinks in Italy, while the sales of sheet glass have been helped greatly by the boom in building industry and by the increased output of motor vehicles.

MELTING *and* FINING

BORAX... a small addition of B_2O_3 to the glass batch, if properly substituted for a part of one or more of the major constituents, will improve the melting temperature and fining rate which should effect economies in fuel and refractory life.

Our representatives are prepared to discuss all the special advantages of B_2O_3 in glass.

PACIFIC COAST BORAX CO.

Division of Borax Consolidated, Limited

New York • Chicago • Cleveland • Los Angeles

SELECTION AND PRODUCTION TECHNIQUES . . .

(*Continued from page* 120)

flat surface and the curvature assumed by it is indicative of the difference in coefficient of expansion, if any, between the two glasses. We have found that this method, if properly done, is accurate to within about 1×10^{-7} in/in/°C. Figure 8 shows the approximate curvatures assumed by various "bi-glass" rods as noted. The figures in parenthesis are the values for the coefficient of expansion $\times 10^{-7}$ in/in/°C., for the particular glass noted.

Glassworking Equipment

Most of the glassworking lathes which we use have been designed and built by ourselves because lathes that are suitable for our particular operations are not available commercially. For instance, the large machine shown in Fig. 9 was designed by one of the authors (J. Gosling) and built in our shops. This machine was specifically designed for construction of the multi-sectioned tubes, an example of which is shown in Fig. 2c. The largest such tube made by us is approximately 11 feet long and has 23 glass sections. These machines are built and maintained to an accuracy equivalent to that of the best machine lathes. A section of our glass production department is shown in Fig. 10.

Acknowledgments

The authors wish to express their thanks to the various people and concerns who have contributed data and information. Dr. Z. J Atlee, formerly with our company and presently Chief Engineer of the Dunlee Corporation, originally directed this work. Particularly we are indebted to Mr. H. R. Black of the Libbey Glass Division, Owens-Illinois Glass Company, for the work and a good part of the data on L650 glass, to Mr. H. P. Hood of Corning Glass Works for data on 866 type glass, and to various people on the technical staffs of the Corning Glass Works, the McKee Glass Company, and the Libbey Glass Division.

A large number of tests on the electrical properties of the various glasses were made by Dr. J. A. M. Lyon of the Northwestern University staff.

Fig. 10. Part of glass production section—General Electric X-Ray Corporation.

REFERENCES

"Glass-to-Metal Seals", A. W. Hull and E. E. Burger, Physics, Vol. 5, p. 384 (1934).
"Glass-to-Metal Seals in Electronic Components and Applications", A. J. Monack, Electrical Manufacturing, p. 96 (Feb. 1947).
"Glass-to-Metal Seal Design", W. J. Scott, Journal of Scientific Instruments, Vol. 23, p. 193 (1946).
"Properties of Selected Commercial Glasses", Technical Products Division, Corning Glass Works (Publication B-83).
"Sealing Glass to Kovar", Stupakoff Ceramic and Manufacturing Company (Bulletin 145).
"Properties of Glass", G. W. Morey (New York: Reinhold Publishing Company—1938).
"Electrical Properties of Glass", J. T. Littleton and G. W. Morey (New York: John Wiley and Sons—1933).

SHORTAGE OF ENGINEERS . . .

(*Continued from page* 122)

Government agencies, including the armed forces, must take cognizance of the situation. Plans must be developed whereby the engineering manpower needs of the services and of industry may be so coordinated that both will be appropriately served from the limited supply. Industry has the job of supporting the military. To assume that the military needs are paramount or exclusive would be a form of national suicide. A careful planning for utilization of men with engineering training and experience only in categories where such training and experience are mandatory should be undertaken; although such can probably not be wholly achieved it is in the interest of the total effort that such an objective be approached as nearly as possible. Sound policies relating to deferment and the calling of reservists must be promulgated with the objective of maintaining a balanced utilization.

It is reported in the technical press that the Russians, in their current five-year plan, are scheduled to have produced 150,000 engineering graduates by the end of 1950. This matches our own output for the same period. During the next five years, however, we will drop by one-third unless drastic action is taken to increase the supply of engineering freshmen and to continue the training operation in full force.

MATERIALS HANDLING CONFERENCE SCHEDULED FOR CHICAGO

Many problems of materials handling in the glass and ceramics industries will be considered at the Materials Handling Conference, according to an announcement concerning the National Materials Handling Exposition scheduled for Chicago, April 30 through May 4.

Three sessions will be devoted to unit loading and packaging methods, a series of recent developments which is engaging major attention among engineers and production executives. One session will consider such unit loading with pallets and skids; a second without pallets, and a third, to the latest developments in unit load packing and packaging.

Other sessions will include a discussion of fundamentals; methods of making a materials handling survey; relationship of handling to other departments; analysis of what constitutes materials handling costs; and methods of presenting a materials handling program to top management. Still another session will be devoted to receiving and shipping methods.

HEARING ON VALUE OF GLASS STOCK

A two-week hearing before Federal Judge Frank L. Kloeb to determine the value of a block of stock in the Fourco Glass Company was completed recently. The dispute is an aftermath of the flat glass anti-trust case which was settled by consent decree in October 1948.

Under the decree signed by Judge Kloeb, the Blackford Glass Company of Vincennes, Indiana, was ordered to sell its stock in Fourco, a sales agency for a number of small glass manufacturers. Both firms were defendants in the case. Attorneys for Fourco and Blackford will have six weeks in which to submit supplemental briefs on how much should be paid for the stock.

NEW GLASS DIVISION DISCUSSED

A group of Canadian glass men and guests met recently to discuss the possibility of organizing a Glass Division within the Canadian Ceramic Society. H. C. Bates, the new Vice President of the Canadian society, presided at this meeting, which was also attended by Cliff Morse of Dominion Glass Co., G. P. Cole of the same company, Ben Matthews of Corning of Canada, and Frank Henkelman of Fiberglas Corp. of Canada. Present in an advisory capacity were C. S. Pearce, Howells Frechette, and W. C. McGolpin and Walter Naish of the National Fireproofing Co.

It was decided that this group should form an informal committee to set up the framework of a division, and to report to the next meeting of the whole society. It was indicated that the growing Canadian industry should be represented in the Canadian Ceramic Society.

PLANT MANAGER NAMED TO EASTERN BRANCH OF OVERMYER

The appointment of James Kindelan as Plant Manager of the Overmyer Mould Company of Pennsylvania has been announced.

Mr. Kindelan served his apprenticeship with the Greensburg Mould & Machine Company and was employed by them as a lathe hand when that company was purchased by the Overmyer organization in 1935 to become the present Overmyer Mould Company of Pennsylvania. In 1937 he was made night foreman and in 1945, was transferred to the day shift in charge of Gortons, Vise, Assembly, and Shipping. In early 1950, he was made factory superintendent.

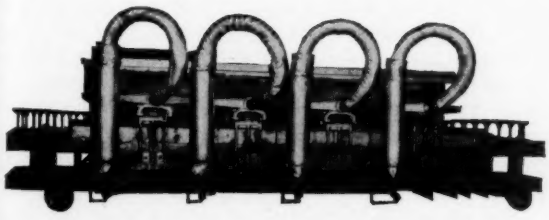
L-O-F NAMES NORTHWEST MANAGER

The promotion of A. C. Boldemann to district manager of industrial and distributor sales for Libbey-Owens-Ford Glass Company in the Pacific Northwest has been announced. He succeeds J. A. Schaumberger, resigned.

Mr. Boldemann, who joined the firm in 1945, has been an L-O-F field representative in northern California for more than five years.

• Chemical Plants Division of Blaw-Knox Company has received a contract to design and construct a safety glass processing unit for the Guardian Glass Company of Detroit, Michigan. In this installation, a high pressure autoclave process will be used to cure the glass and set the resin bond, thereby producing a high quality safety glass for automotive, aircraft, and similar uses.

FIRE POLISH WITH OIL



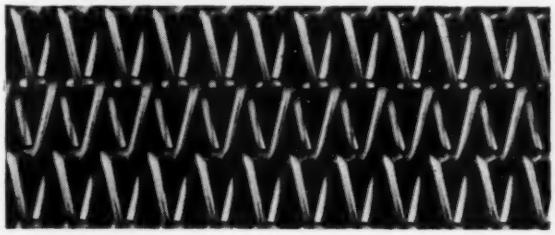
Oil-fired, fire polishing machines for all types of pressed ware. Available for hand, semi-automatic or full automatic operation. Whatever your fire polishing problem, Stewart-Glapat machines will solve it efficiently and economically.

Write for Bulletin 40E

STEWART-GLAPAT CORPORATION
ZANESVILLE, OHIO

FIRE POLISHERS • CONTAINER FINISHERS •
BURN-OFFS • THE UNIVERSAL LOADER •
ADJUSTOVEYORS • GLASS CONVEYORS •

WISSCO BELTS



The answer to processing problems

Because of their open-mesh construction, Wissco Metal Processing Belts provide the advantages of complete heat circulation, low thermal capacity and limited surface contact in the annealing and decorating of glass and ceramic ware.

Every Wissco Belt is custom-engineered for its particular job —fabricated of special alloys to operate efficiently and dependably at temperatures up to 2100°F.

Send for our illustrated booklet showing numerous types and advantages of Wissco Processing Belts.

WISSCO METAL PROCESSING BELTS CF&I

A PRODUCT OF WICKWIRE SPENCER STEEL DIVISION OF THE COLORADO FUEL & IRON CORPORATION
Sales Office and Plant—56 Sterling Street, Clinton, Massachusetts
Executive Office—500 Fifth Avenue, New York 18, New York
Sales Offices—Atlanta • Boston • Buffalo • Chicago • Denver • Detroit • New York • Philadelphia
Pacific Coast—The California Wire Cloth Corporation, Oakland 6, California

POLARISCOPES
for
Qualitative Observation
•
POLARIMETERS
for
Quantitative Measurement
•
POLARIZING INSTRUMENT CO., Inc.
273 N. Bedford Road
Mt. Kisco, N. Y.

AMCO
Design, Erection
and Operation
of
Manufacturing Plants
and
Furnaces
for
All Types
of
GLASS WARE
AMSLER MORTON
CORPORATION
CHAMBER OF COMMERCE BUILDING, PITTSBURGH 19, PA.

CORNING'S GLASS CENTER . . .

(*Continued from page* 127)

serving mankind at Mount Palomar. These are the largest pieces of glass ever cast. The first one, heretofore on public display by the Chamber of Commerce in the town square, will be illuminated from behind. It will seem to float in space surrounded by photo-murals of galaxies and nebulae on either side. In contrast, in a small case will be a single little piece of glass, an Egyptian amphorisk of the 18th Dynasty made by the core-wound process nearly 4,000 years ago.

Many hundreds of items of rare glass, of all periods and from all parts of the world, have been assembled for the Museum exhibit, as have many hundreds of rare books, prints, and other published items about glass, in many languages and going back through the centuries.

It is intended to provide the researcher with glass objects and printed matter representing every field and period of glassmaking in history. Spokesmen at the meeting said that the three-fold expansion of research facilities, involving the comprehensive Library and Museum and the Steuben plant with spectator galleries, would afford immediate service to the entire glass industry as well as serving mankind generally.

Glass Used in Building

The Glass Center itself, from the physical standpoint, will demonstrate many uses of glass, for glass will be used for the exterior walls, where it will be combined with steel, and also for parts of the roof, interior walls, floors, and divisions. Uses of glass from blocks to fiber draperies will be involved. All the qualities of glass will be emphasized, from hardness and protective characteristics which make it suitable for sanitation and longevity, to its absorbency in fiber form when employed for insulation and acoustical treatment.

It is intended by Corning Glass Works, its spokesmen said, that the mission of the Glass Center shall be greater than the interests of a single company or industry and will be pointed to the broader purpose of serving mankind. It was stated to the audience that glass has served man with more useful purposes than any other material and enters into every aspect of living. The listeners were reminded that glass is believed to be civilization's earliest industry and was the first in the New World, glassmakers having been brought to the Jamestown Colony in 1608 to make beads for the Indian trade.

Several appointments in connection with the Glass Center were announced. Rushmore H. Mariner, heretofore head of the New Products Department and assistant to the Chairman of the Board of Corning Glass Works, is directing the development of the Glass Center. James M. Brown, 3rd, who has been Director of the William A. Farnsworth Museum in Rockland, Maine, has been named Director of the Corning Glass Center.

The Director of the Corning Museum of Glass is Thomas S. Buechner, hitherto with the Metropolitan Museum of Art, New York. Dudley Olcott, until now manager of sales service of the Consumer Products Division of Corning, becomes Business Manager of the Glass Center. E. P. H. James, Director of Public Relations for the project, formerly was Vice President of the Mutual Broadcasting System.

CLASSIFIED ADVERTISEMENTS

GLASS SPECIALIST CAN DELIVER: All recipes for bottles; flasks; window glass; technical, laboratory, flexible glasses; crystal, table, colored glasses; lighting, signaling, tube, bulb glassware; optical glasses; buttons; beads; enamels; glass decolorizers. All building plans for glass tanks, pot furnaces, modern annealing lehrs, bending furnaces, toughening plants. Excellent references. Ing. J. Schnurpfeil, Dr.h.c., Glass Specialist, P. O. Box 2392, Istanbul-Beyoglu, Turkey. Telegrams: AGWIN Istanbul.

RESEARCH DIGEST . . .

(*Continued from page* 133)

The origin of the forces responsible for the tension causing fracture appears obscure. Observation proves that hackle is most prevalent when the fracture surface runs at an angle of roughly 45° to a pre-existing free surface. Fractures produced by transient shock waves in glass lead one to consider the possibility of the reflection of compression and tension waves setting up areas in which a shock front exists. A shock front may be the cause of hackle.

DR. SILVERMAN HONORED BY CHEMISTS INSTITUTE

On February 6, Dr. Alexander Silverman, Head of the Chemistry Department in the University of Pittsburgh, was made an Honorary Member of the American Institute of Chemists "for promoting a better understanding of applied chemistry by lecture, by precept, and by unselfish service to the Chemistry profession".

Dr. John R. Bowman, Director of Pure Research in Physical Chemistry, Mellon Institute, presided at the ceremony. Dean Stanton C. Crawford of the College, University of Pittsburgh, spoke of the development of the Chemistry Department in teaching and research during Professor Silverman's 45 years of service.

In the absence of President Lawrence Flett of the Institute of Chemists, who was detained by the railroad strike, Dr. Walter J. Murphy of Washington, D. C., Gold Medallist of the Institute and Editor of *Industrial and Engineering Chemistry*, presented Professor Silverman with the certificate of honorary membership in the Institute, commenting on his contributions to and interest in scientific literature. Professor Silverman, in accepting the certificate, stated that his accomplishment was due to the full cooperation of his colleagues, his students, and his associates in the science field. He then spoke on "Teaching as a Fine Art".

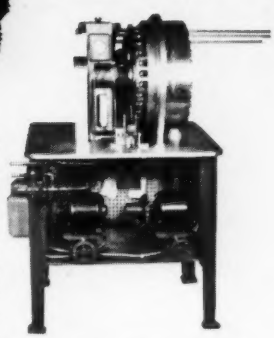
AMERICAN NEPHELINE EXPANSION

American Nepheline Ltd., manufacturers of Lakefield Nepheline Syenite who are represented in the United States by Great Lakes Foundry Sand Company, Ceramic Division, is planning an expansion of production facilities which will make available an additional 2000 tons per month of glass and pottery grade material in order to take care of the steadily increasing consumption of this material in the glass and whiteware industries.

At the mine at Blue Mountain, a new administration building has been erected, together with a chemical and physical control laboratory.

KAHLE specialists in custom built glass-making machinery

#1507
HIGH SPEED AUTOMATIC GLASS TUBING CUTTING MACHINE



All Kahle equipment is custom-made — we don't turn out *stock* machinery. That's why we can do a better job for you — all our engineering skill and experience is concentrated on your specific glass manufacturing or finishing problem.

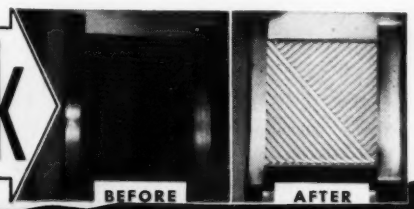
High production on specific diameters. 30 head, continuous drive. Variable speeds. Length of cut adjustable. 7500-15,000 pieces per hour.

We're Specialists in equipment that cuts costs, increases production, assures uniformity in the manufacture of: ampules • cathode ray tubes • standard, miniature, sub-miniature radio tubes • sub-miniature tubes • fluorescent lamps • incandescent lamps • photocells • x-ray tubes • glass products.

Consult Kahle! There's no obligation. Write for our complete, new catalog today!

Kahle ENGINEERING COMPANY
1308 Seventh Street
North Bergen, New Jersey, U. S. A.

Look

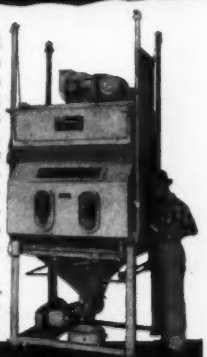


Hydro-Finish *Speeds Up* Polishing of Glass Molds

VIRTUALLY ELIMINATE all hand cleaning and polishing of glass molds with Pangborn *Hydro-Finish!* Cleans molds faster than other methods yet holds tolerances. Maintains sharp edges and contours, leaves molds ready for use.

Complicated molds or designs are easily cleaned *throughout* because Hydro-Finish uses fine-mesh abrasives suspended in water, impelled through controlled feed. By holding tolerances to .0001, Hydro-Finish substantially increases life of molds.

FREE: Write for Bulletin 1400-A to: PANGBORN CORP., 3400 Pangborn Blvd., Hagerstown, Maryland.



Pangborn
BLAST CLEANS CHEAPER
with the right equipment for every job